## *An experimental investigation of the benefit derived from the employment of specially designed equipment for instruction in fundamental electrical and radio theory*

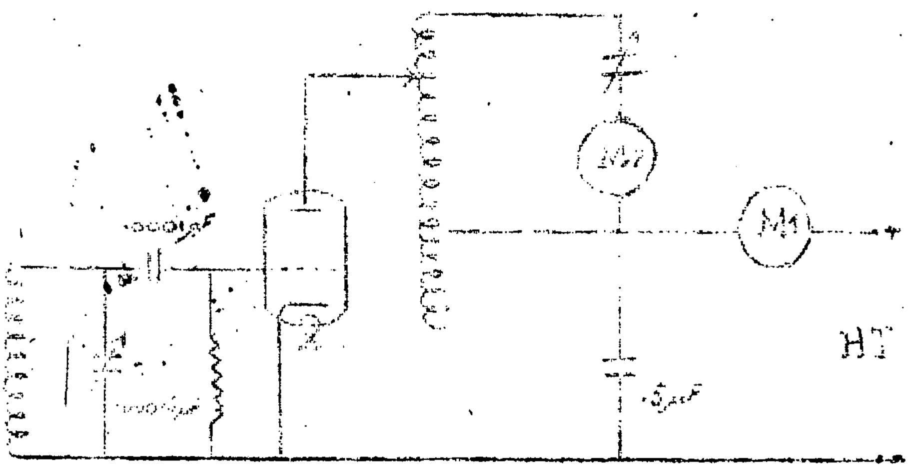
Claxton, Maurice E.

GENERAL INSTRUCTIONS:

1. Before staring any experiment a circuit diagram must be drawn in your practical notebook.
2. Whenever a question is asked or current required an answer must be given in the notebook.
3. Whenever an H.T. or L.T. circuit is to be wired such connections mus be most carefully checked for shorts before switching in power supplies.

1. T.A.T.G. Oscillator.

(a) Using a small indirectly heated triode M.L.6 (V.T.105 in T.1154) wire up a series for TATG oscillator as shown in the following diagram.




Note the heater of the valve is already wired to the L.T. terminals at the top of the board. The grid coil is a small inductance wound to tune over the same range as the anode circuit and the choice of grid leak is left to the operator.

(b) Having checked the wiring, make sure that the mains supplies 6.3v A.C. for L.T. and 250v D.C. for H.T. are both switched off. The switches are located to the left of the power socket. Insert this power plug and switch on L.T. ONLY. Ascertain that the valve lights, then switch on H.T.

(c) With the grid condenser set to mid-position adjust the anode tuning control for an indication of maximum oscillatory current as shown in

M2. Comment in your practical notebooks on the significance of the variations of reading of M1, the supply meter, and the corresponding readings of M2, the oscillatory current meter, as the anode circuit tuning is altered.

(d) Taking the efficiency of working of the oscillator for a given grid setting as the ratio of oscillatory current to supply current, adjust the anode tap and select that value of grid leak for maximum efficiency. Why should these adjustments control the efficiency of working?

(c) Using the wavemeter W.1117 ascertain at what frequency your oscillator is operating. Beware of harmonics.

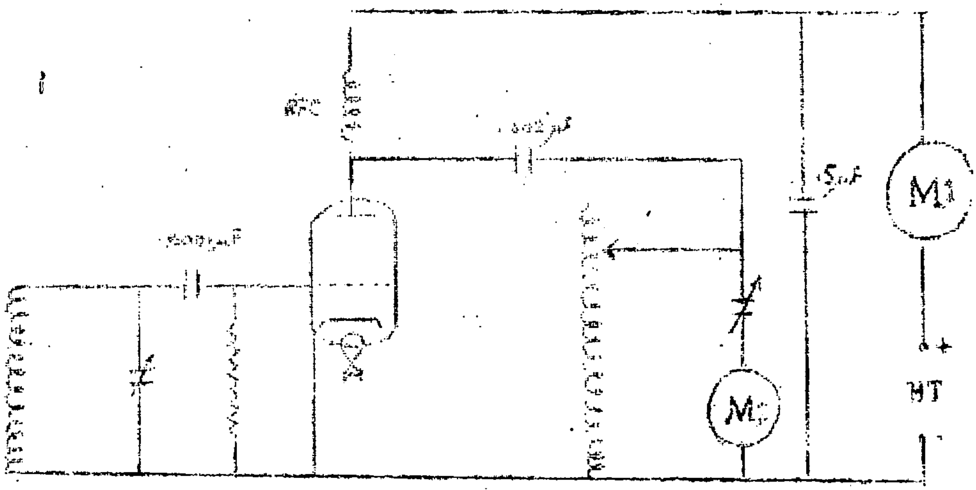
(f) Select any frequency between 3,000 Kc/s and 5,000 Kc/s and adjust your oscillator to operate at the freq:.
N.B. Setting up the desired frequency can best be accomplished in the following way:- Since from (e) above the operating frequency is already known it is apparent whether an increase or decrease of frequency is necessary to reach the desired frequency. Thus the direction in which the anode and grid condensers must be altered is known. The final approach to be desired is then made:
Alter the grid tuning a few degrees in the right direction, then adjust the anode tuning for maximum oscillatory circuit. Determine the new frequency with the aid of W.1117, and repeat this procedure until either the desired frequency or frequency very close to the desired frequency is obtained. Final adjustment may be made by setting W.1117 to the desired frequency, adjusting, in order, the grid tuning, then the anode tuning, for maximum indication in the wavemeter.
NOTE: Use the wavemeter sensitivity control to guard against overloading the meter.

(g) When the oscillator is functioning touch the grid terminal. What happens? Why is this?

2. Parallel Fed T.A.T.G. Oscillator.

(a) Rewire the oscillator board to the following circuit:

See page No.3 for diagram.




(b) Select any frequency between 3,000 Kc/s and 5,000 Kc/s and adjust the oscillator to that frequency. This operation can best be effected by setting the grid condenser to mid-position, tuning the anode circuit and estimating the frequency of operation. The procedure detailed in 1(f) should be used.

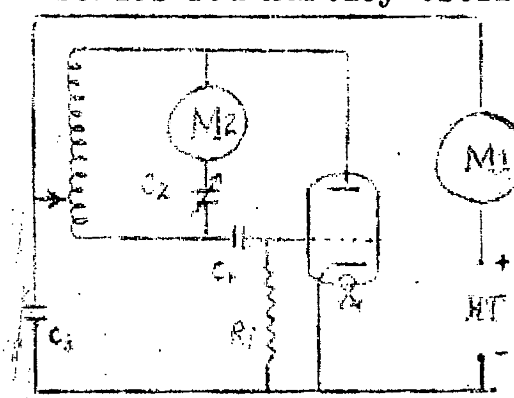
(c) Apply a shunt across the R.F.C. What happens? Why is the inclusion of an RFC necessary when using parallel feed to an oscillator?

(d) What purpose does .002 μF condenser serve?

(e) If the reading in the supply meter becomes abnormally high what components would you suspect as faulty?

3. <u>The Hartley Oscillator:</u>  <u>Series Fed.</u>.

(a) Using an M.L.6 (V.T.105) wire up the following series fed Hartley oscillator circuit




C1 = .0001 μF
C2 = .00015 μF variable.
C3 = .5 μF
R1 = 100Ka, 50Ka, or 10Ka
M1 = 0-50mA D.C.
M2 = 0-500mA R.F.

(b) Adjust the oscillator for maximum efficiency by varying the position of the H.T. tap and select the most suitable value of grid leak. What further efficiency adjusting device could have been provided? Refer to the circuit diagram of T.1087 M.O. Section. Why should any alteration of H.T. tap vary the efficiency of operation?

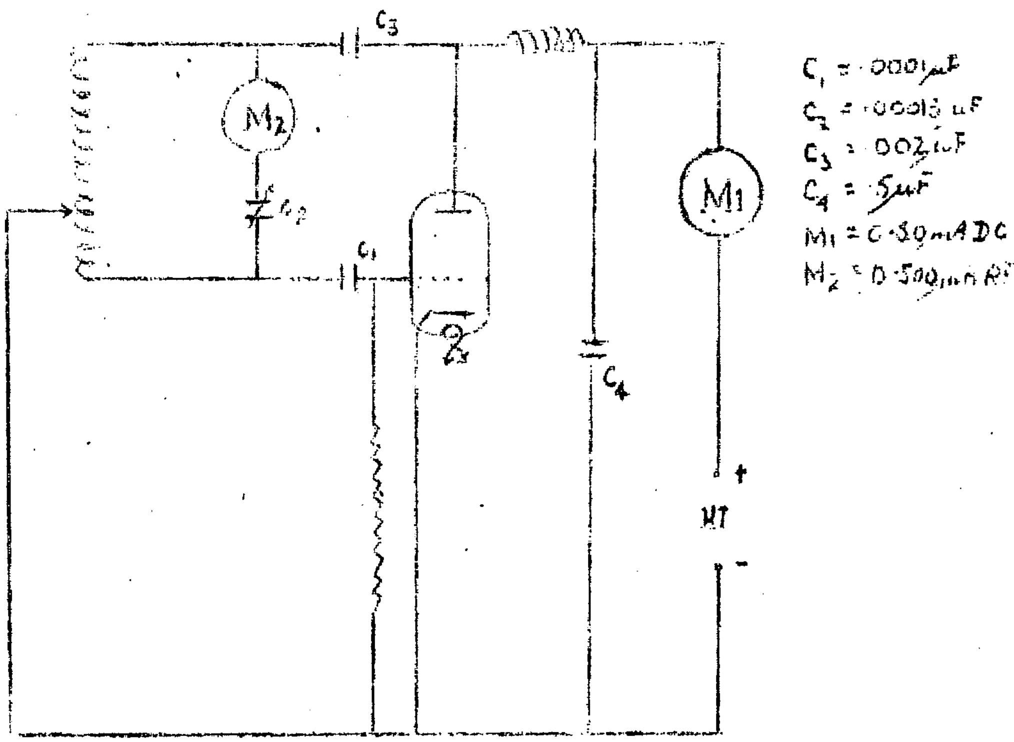
(c) Set C2 to its mid-position and estimate with the aid of W.1117 at what frequency the oscillator is operating.
NOTE: Make sure that it is the frequency of YOUR oscillator which you are measuring. What is the easiest way in which to check this?

(d) Choose any frequency between 4,000 Kc/s and 6,000 Kc/s and adjust the oscillator to that frequency. Why is this adjustment much easier when employing this type of oscillator?

(e) Touch the grid terminal when the oscillator is operating. What happens? Why is this?

4. Hartley Oscillator - Parallel Fed

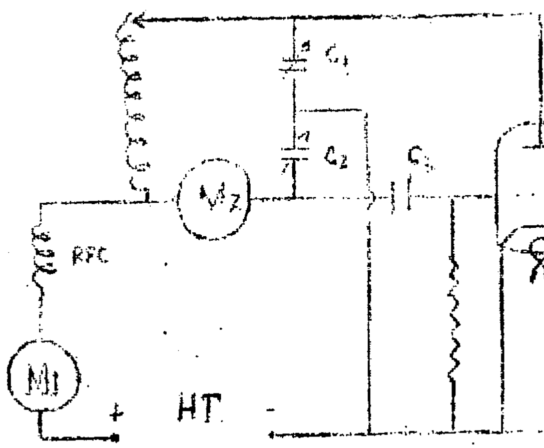
(a) Rewire the oscillator to be parallel fed as below:-



(b) Adjust the oscillator to operate at a selected frequency between 4,200 and 6,000 Kc/s.
(c) What purpose does the condenser C4 serve? What governs the choice of such a condenser?
(d) How could you easily check that the oscillator was functioning, if a wavemeter or oscillatory current meter was not available. Explain the mode of operation of your test.

5. The Colpitts Oscillator - Series Fed.

(a) Using a V.T.105 (M.L.6) wire up the following series fed Colpitts Oscillator.

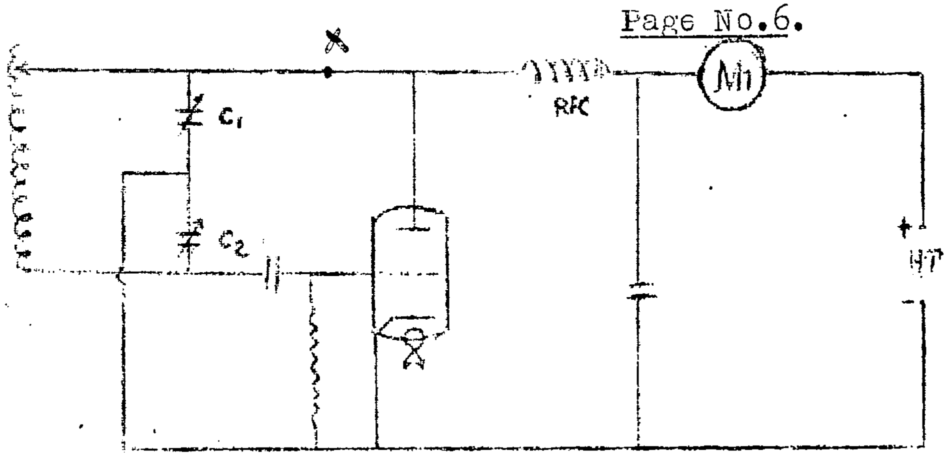



C1, C2 .00015 μF (Var)
C3 .0001 μF
C4 .5 μF

(b) For L use the whole of the inductance on the board. Set C1 to its minimum position and vary the setting of C2 until maximum oscillatory current is obtained. Why should the setting of C2 vary the amplitude of oscillatory current?
(c) With the aid of W.1117 estimate the frequency of oscillations. Beware of harmonics. The fundamental will, in general, be that frequency at which the amplitude of oscillations is a maximum. This is not always true. Why?
(d) By adjusting the settings of C1 and C2 set up the oscillator to operate at half the frequency obtained in (c) above.
(e) Adjust the value of inductance and the variable capacities until the frequency of oscillations is double that obtained in (c).
(f) What purpose does the RFC in HT lead serve? What other component might be used instead? (Refer to circuit diagram of het.osc. in R.1155).

6. Colpitts Oscillator - Parallel Fed.

(a) Rewire the above circuit so that a parallel fed Colpitts Oscillator is obtained




NOTE: That no oscillatory current meter is used.

(b) By varying the amount of inductance in circuit and by adjusting C1 and C2 set up the oscillator at 4,000 Kc/s.

(c) How is it possible to obtain a visual indication that the oscillator is functioning.

(d) Why is it not essential to provide a fixed condenser at X? On what grounds might the inclusion of such a condenser be considered desirable?

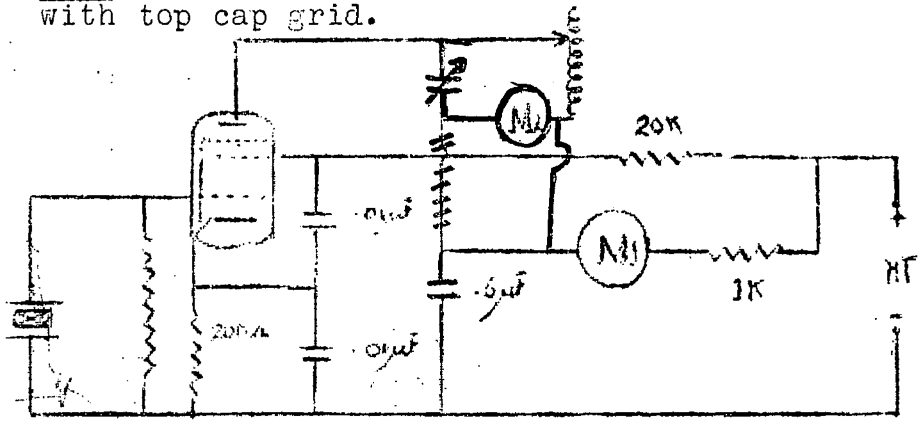
(e) If the RFC burnt out, what would you suggest as the probable cause of the trouble?

(f) If the meter, but not the RFC burnt out, what might be the trouble?

(g) Are either of the faults likely with the present apparatus?

7. Tuned Anode Crystal Grid Oscillator. (Miller).

(a) Wire up the following oscillator circuit using a small A/F Pentode V.T.52 (Crystal Oscillator T.R.1133).
NOTE: This valve has an international octal base with top cap grid.



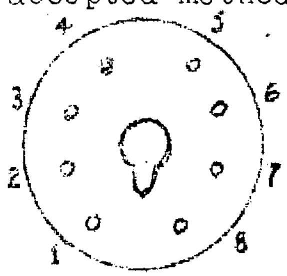
It should be noted that the screen supply and the cathode biassing are both fixed below the board.

(b) Complete the circuit as indicated in the above diagram. Insert a crystal of frequency between 4250 Kc/s (Stores Ref: No: 10X/4250) and 6220 Kc/s (Stores Ref: No: 10X/6220).

(c) Vary the tuning of the anode circuit and draw a graph in your notebook to indicate the relation between anode current of the valve and increase of capacity in the anode circuit. Why does the curve "dip"? What is meant by the slow side of a dip, and why should crystal oscillators be set 10% in the slow side?

(d) In what way is the valve safeguarded when cathode bias is employed?

(e) The figure below indicates the underside view of an actual octal valve holders and illustrates the accepted method of numbering the pins.




Underneath View.

Remembering that V.T.52 is an A/F Pentode in which the suppressor is invariably internally strapped to cathode, complete the valve pin diagram at side.

Thus V.T.52
Pin 1. Blank.
2. Heater
3. Anode.
4. Screen.
5. Blank.
6. No Pin
7. Heater.
8. Cathode
Top Cap Control Grid.

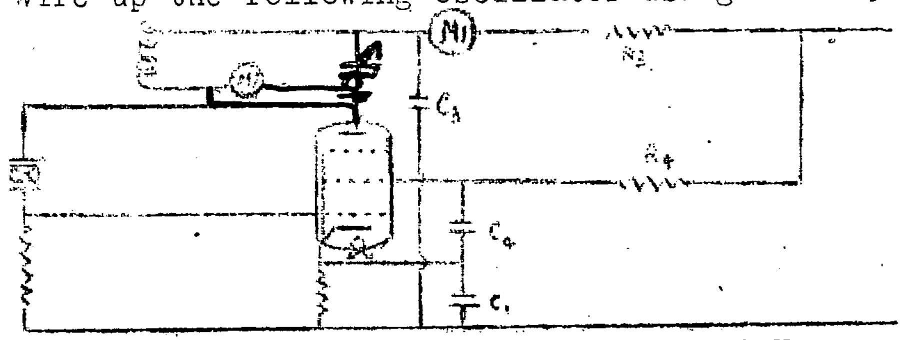
(f) Check the calibration of the W.1117 by tuning it to the crystal fundamental and noting the discrepancy between the frequency as indicated by the calibration chart and that of the crystal.

(g) Continue checking the calibration of the wavemeter by tuning to second and third harmonics of the crystal.

(h) Bearing in mind that the magnitude of the wavemeter deflection is proportional? to the magnitude of oscillations, compare the amplitude of oscillations of fundamental, second and third harmonic of crystal. Is this true? Give reasons.

8. <u>The Pierce Oscillators - Crystal Anode Grid Oscillator</u>

(a) Wire up the following oscillator using a V.T.52.



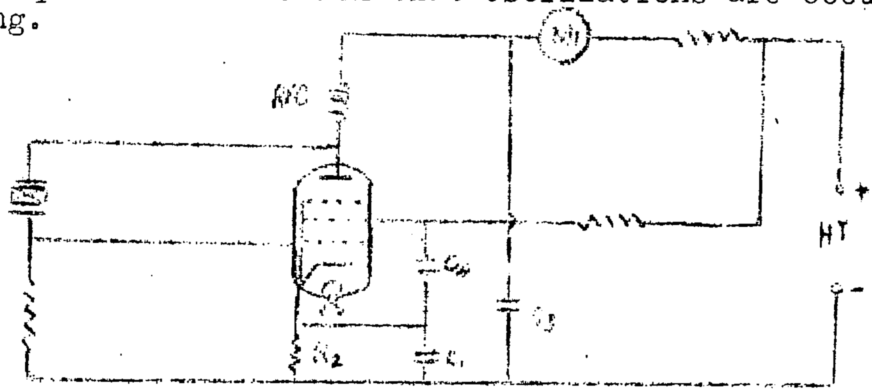
| | | | | | |
|---|---|---|---|---|---|
| C1 | - | .01 µF | R1 | - | 100 K |
| C2 | - | .00015 µF | R2 | - | 200 ohms |
| C3 | - | .5 µF | R3 | - | 1K |
| C4 | - | .01 µF | R4 | - | 20 K |

(b) Vary the anode tuning until the oscillations occur. Note it may be necessary to alter the amount of inductance as well as varying the setting of C2.

(c) When it has been ascertained that the anode circuit can be tuned draw a graph in your notebook to indicate the relation between anode current of the valve and variation of anode cct capacity as the capacity is <u>increased</u>. Contrast this curve with the one obtained when using the tuned anode crystal grid oscillator and comment on the difference.

(d) Adjust the anode tuning so that the oscillator is "10% on the slow side". Use the wavemeter to prove that harmonics of the crystal are being generated.

(e) Remove the crystal and replace it with one of higher than one of lower frequency. Comment on the results. Note that the crystal monitors (i.e. Crystal Monitors, Types 1 and 2) employ a Pierce Oscillator circuit. What advantage in respect of a simplified anode load can be claimed for the Pierce oscillator? Verify your conclusions by setting up the following Pierce circuit. Plug in crystals of differing frequencies and check that oscillations are occuring.




R1 100 Kπ
R2 200 π
R3 1 K π
R4 20 Kπ

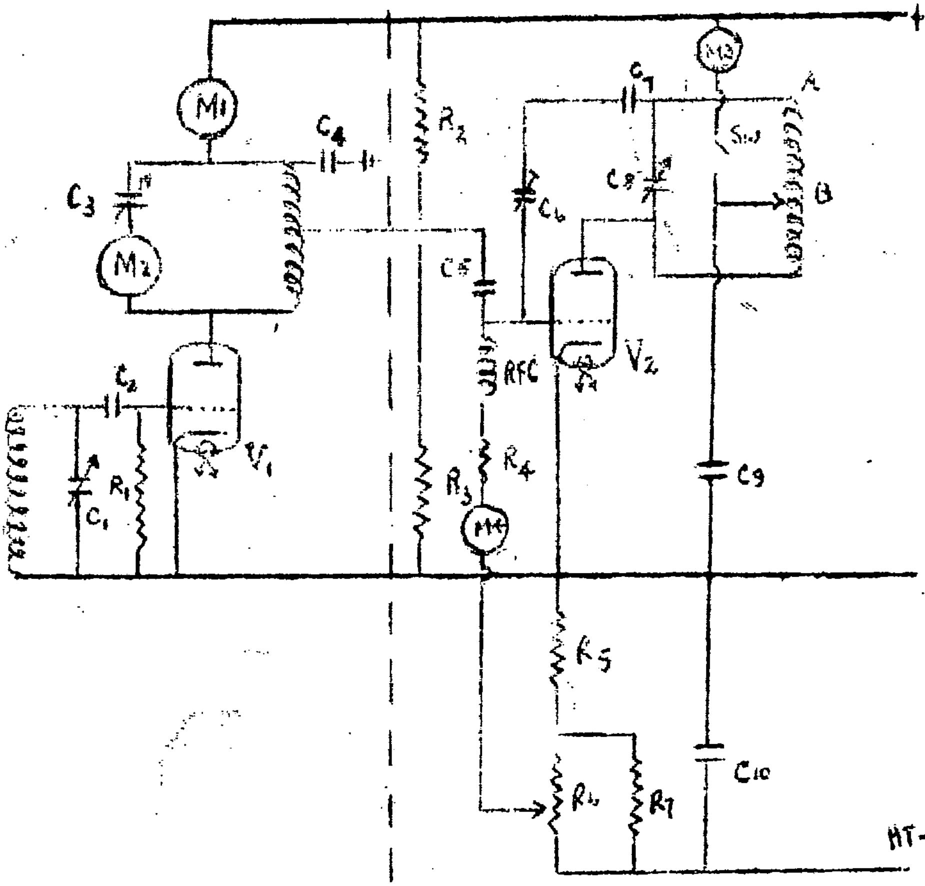
C1 C4 .01 μF
C3 .5 μF

Instructions for the Operating of Power Amplifier Boards and Assembly of Simple Transmitter.

1. Neutralised Triode Power Amplifier.

(a) Wire up the following circuit using two M.L. 6 (V.T.105) one valve for oscillator the other as amplifier. It will be appreciated that this instruction involves the use of both the oscillator and power amplifier boards.

See Page No.10 for diagram.




C1 .00015 µF variable
C2 .0001
C3 .00015 µF variable
C4 .5 µF
C5 .0005 µF
C6 3 - 40 µµF
C7 .002 µF
C8 .00015 µf variable
C9 .005 µF
c10 2 µF

R1 = 30 K
R2 = 10 K
R3 = 30 K
R4 = 50 K
R5 = 500 ohms
R6 = 2 - 10 K.Pot.
R7 = 1 K

M1 0-50Ma DC
M2 0-500Ma RF
M3 0-75Ma DC

NOTE: A should be the end tap in P.A.anode coil and B the next tap. It may be necessary to move B further down the coil.

(b) Disconnect the lead from C5 to oscillator anode circuit at X, and adjust the oscillator to operate at a given frequency between 3,000 and 5,000 Kc/s. (Consult the instructor and see page 1 para:(f) for method of setting up to given frequency).

(c) With Sw closed adjust R6 until there is no reading in M3. On what point on its characteristic is V2 operating? How is this condition secured?

(d) Open S and connect C5 to No.3 tap on oscillator anode circuit. Why is an indication obtained in M4?

(e) Vary the P.A. anode tuning until max: dip is obtained in Ma. Why should this occur? Adjust C6 until on rotation of Cλ minimum change occurs in reading of M4. 8 This process of neutralising is employed in T.1131 the ground station VHF transmitter. Why should neutralising be necessary?

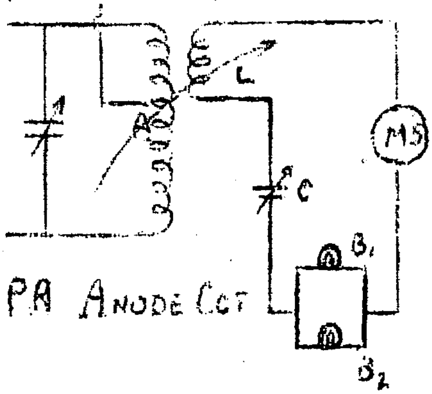
(f) Close S and adjust anode tuning for minimum feed to V2. When will this occur?

A simple M.O.P.A. has been constructed.

NOTE. <u>ALWAYS SWITCH OFF H T BEFORE MAKING CIRCUIT CHANGES.</u>

2A <u>Loading the P.A. Stage Method A.</u>

The transfer of power to an aerial can be simulated by the employment of the following aerial (artificial).

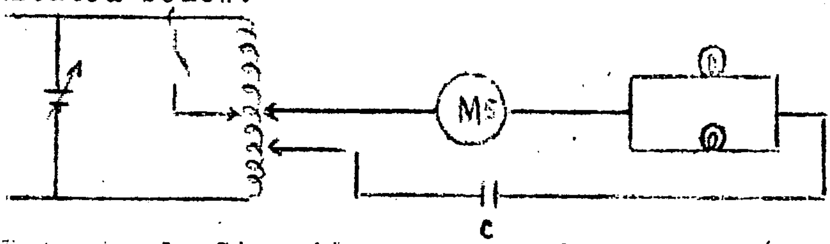



L - adjustable coupling coil
C - .00015 µF
B1 B2 Lamps 24v 6W
M5 0 - 500 Ma R.F.

The artificial aerial board must have the same number as the P.A. board, and is to be connected to the latter by the lugs provided, thus ensuring that the aerial coupling coil will not foul the P.A. anode coil.

Starting with small value of coupling tune the aerial for maximum indication in the aerial current meter. Retune the P.A. stage if necessary. Why may this adjustment be required? Increase the coupling retuning aerial and P.A. stages until maximum output is obtained. What value has this output? How does the P.A. feed change as the coupling between P.A. anode circuit and aerial is increased.

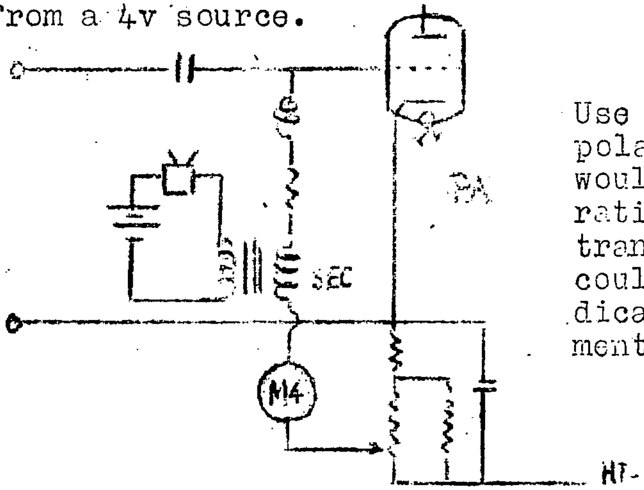
Why should this change occur? What variation of reading occurs in the grid current meter and the feed meter to the oscillator when the P.A. anode circuit is tightly coupled to the aerial?
How does your method of adjustment and metering enable you to prove that the amplifier is working under Class C conditions?
Vary the drive to the amplifier stage in order to obtain maximum output.
Obtain an estimate of the power efficiency of the stage by comparing the power dissipated in the artificial aerial with the calculated power supplied to the P.A. stage obtained from metering and measurement of the P.A. supply voltage. How could you increase this efficiency?
B. Loading the P.A. Stage Method B.
The link coupling coil of the artificial aerial is to be disconnected and the lamps and meter capacitatively coupled to the P.A. anode circuit as indicated below:




P.A. Anode Circuit C = .01 μF (Fixed)

T1 is an adjustable tap on the P.A. anode circuit whilst T2 is connected to the same point as the H.T. feed.
Starting with T1 close to T2 and returning the P.A. at each adjustment vary the position of T1 until maximum power is transferred to the artificial aerial circuit.
Why should alteration of tap T1 affect this transfer?
3. Keying the Transmitter.
Place the key in the H.T. negative line and monitor the radiated signal on one of the laboratory receivers. Try and account for the quality of the transmission.
4. Grid Modulation of the Transmitter.
Grid modulation of the power amplifier can be obtained by working the stage under Class B and Class C conditions and varying the bias at audio frequency.

Why cannot Class A condition be used?
Modify the grid of the P.A. stage to include the secondary of the microphone transformer on the P.A. board. Connect the primary of the microphone transformer in series with a carbon microphone energised from a 4v source.




Use two 2v 20 AH accs to polarise microphone. What would you imagine the ratio of the microphone transformer to be? How could you obtain an indication by measurement?

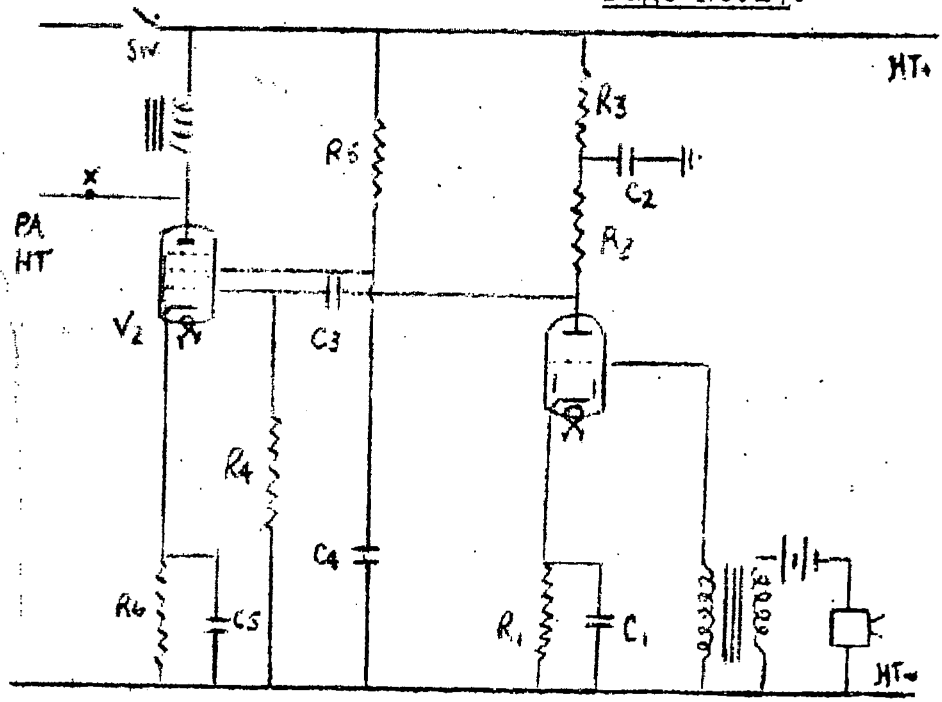
Test the quality of transmission by monitoring on a laboratory receiver. What visible indication exists to show that the modulation occurs? How could the depth of modulation be increased whilst still using the same microphone circuit and type of modulation? Draw an Ia Vg diagram to illustrate the operation of this type of modulation.

5. Anode Modulation of the Transmitter.

For this purpose a two stage audio amplifier is to be used.

Why should this be necessary? Wire up the following circuit on the anode modulation board:-

See Page No.14 for diagram.




Anode Modulation Board

V1 MHLD 6(V.R.101)
V2 E L (V.T.52)

R1 1000 OHMS
R2 50 K "
R3 20 K "
R4 500 K "
R5 10 K "
R6 500 or 1000π

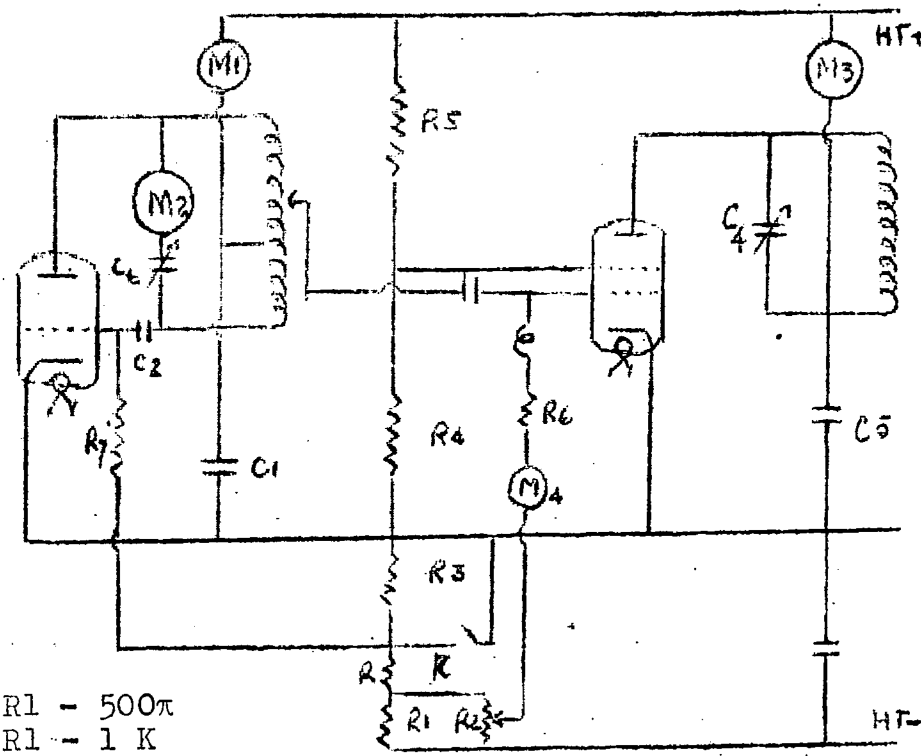
C1 - 4 μF or 2μF.
C2 - 4 μF
C3 - .01 μF
C4 - 5 μF
C5 - 4 μF or 2μF

What purpose does the combination C2 R3 serve? In some cases self oscillation of the amplifier can be prevented by reversing the secondary connections of the microphone transformer. The transmitter wiring should next be altered so that the P.A. section receives its H.T. supply from the point marked X in the modulation circuit. Why is this?

Monitor the output of your transmitter on one of the laboratory receivers adjusting the bias in the P.A. stage for maximum depth of modulation. What economy is effected by endeavouring to maintain a high depth of modulation? Comment on the statement that the audio power supplied by modulation is three times the R/F power supplied by the P.A. stage. Check the waveform of your modulated wave by applying the R.F. voltage developed across the P.A. anode circuit to an oscillograph (use D.C. isolating condensers).

6. <u>Construction of Transmitter using Beam Tetrode as P.A. Stage.</u>

Wire up the following circuit:-




R1 - 500π
R1 - 1 K
R2 - 10 K Var:
R3 - 5000
R4 - 50 K
R5 - 10 K
R6 - 50 K
R7 - 50 K

C1 - 2 μF
C2 - .0003 μF
C3 - .0003 μF
C4 - .00015 μF Var: e.g. .005 μF
C5 - .5 μF
C6 - .00015 μF Var:
C7 - .0001 μF
K - Key

V1 - ML (VT 105) - R.C.A. 807 (V.T.60).

Measure the voltage developed across R3 with an A.V.O.
(NOTE: Start on highest volts range) when the key is open.

Is the M. O. oscillating?

Close the key and measure the voltage across R3 again.

Is the M.O. oscillating now? Account for the fact that oscillations accur now whereas they did not previously.

Tune the P.A. to the M.O.. How is this done?

Adjust the artificial aerial coupling and the bias to the P.A. stage for maximum output.

Is the P.A. stage inoperative when the key is open?

Try the effect of grid and anode modulation on this transmission and compare the results of monitoring your transmission with those obtained when using the previous transmitter. Comment on the quality of keying when using C.W. and quality and depth of modulation when using R/T.

What big advantages has the R.C.A.807 over an M.L.6 when used as a power amplifier? Under what conditions is this benefit not secured?

7. Crystal Controlled Transmitter.

(a) Use a crystal oscillator as described on pages 7 and 8 as the drive unit, and, as previously, use either a neutralised triode or a beam tetrode as P.A. stage. Why is a better note obtained when monitoring this transmitter?

(b) Give the P.A. stage maximum bias and tune it to double the crystal frequency.

Of what general advantage is this process?

## GENERAL INSTRUCTIONS.

1. Before starting any experiment a circuit diagram must be drawn in your practical notebook.
2. Whenever a question is asked or current required an answer must be given in the notebook.
3. Whenever an H.T. or L.T. circuit is to be wired such connections must be most carefully checked for shorts before switching in power supplies.

## Instructions for operation of Receiver Boards.

1. (a) Simple one valve detector.
   (b) Employing an MHLD6 (double diode triode V.R.101) wire up the following circuit using an aerial tuning board and a detector board.

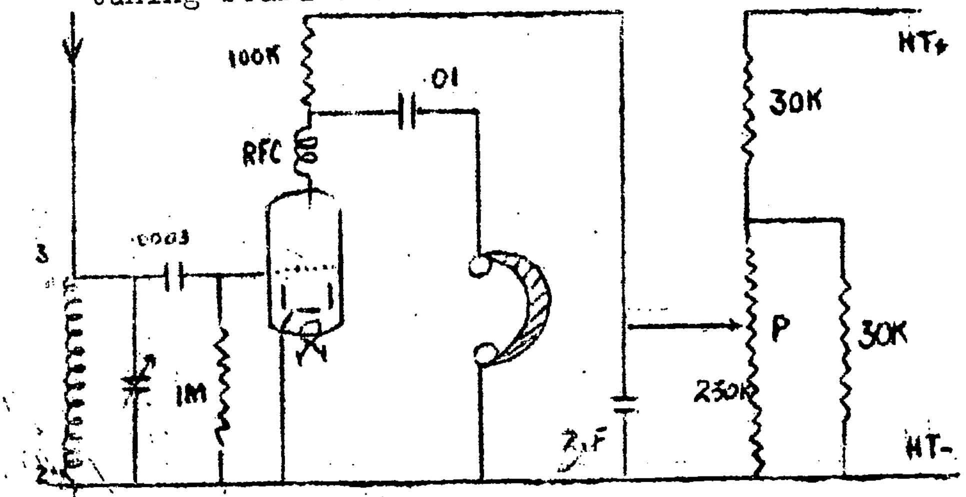



FIG 1

The aerial tuning coil to cover the medium frequency broadcast band is marked medium "f" and has three windings, the base connections from the underneath being as shown.

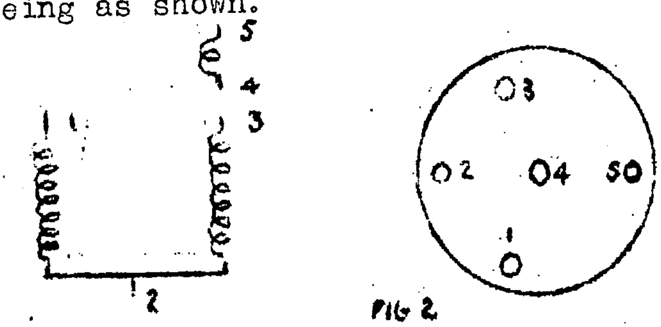
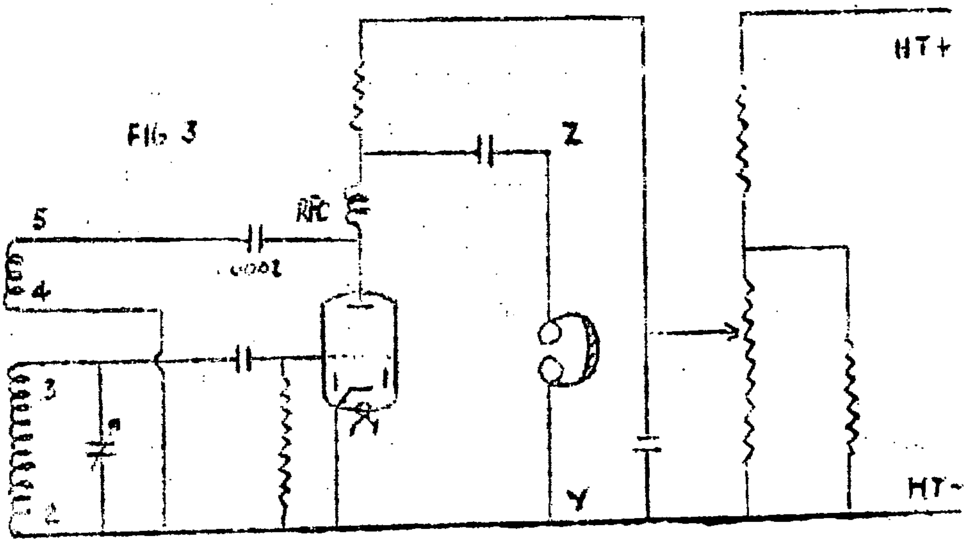



FIG 2.

Adjust the potentiometer P for maximum voltage at the anode of V, and search for a signal. If no signal is obtained rewire circuit as indicated in Fig:(ii).

2. Simple Receiver with Regeneration.

FIG 3




Adjust the grid tuning and potentiometer P for maximum signal strength. Account for the increase in signal strength as compared with the previous receiver. (Note. If there is no increase in signal strength reverse the connections to 4 and 5. Why is this?). What components effect the amount of regeneration? What effect is obtained if the reaction is fed from the end R of the R.F.C?

3. Rewire the simple receiver as below:-

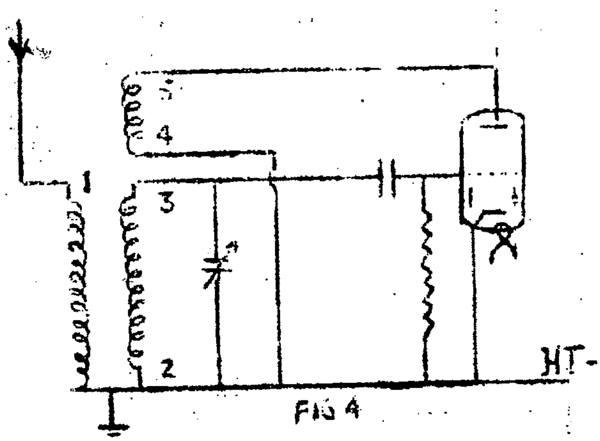
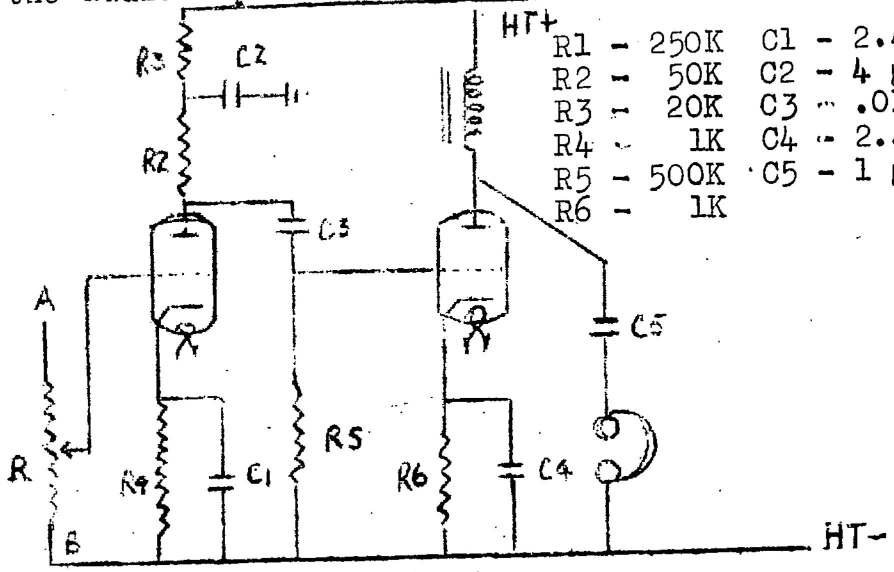



FIG 4

Why is it necessary to retune the grid circuit to obtain maximum signal strength? What advantage does this receiver possess over the first one constructed? Has this advantage been achieved at any apparent cost? If so, why?

Audio Frequency Amplifier. (Resistance Capacity Coupling).

1. Using two M.L.6.s wire up the following circuit on the audio amplifier board:-




| | | | |
|---|---|---|---|
| R1 - | 250K | C1 - | 2.4 µF |
| R2 - | 50K | C2 - | 4 µF |
| R3 - | 20K | C3 - | .01 µF |
| R4 - | 1K | C4 - | 2.4 µF |
| R5 - | 500K | C5 - | 1 µF |
| R6 - | 1K | | |

FIG 5

What purpose do the condensers C1 and C4 serve? What is the true "Audio load" of V1? Why are C2 and R3 employed in the circuit? Could R3 be replaced by a smaller resister?? What other component would have to be changed to produce the previous effect? Connect the points A and B to the points Z and Y of Fig: 3 or 4. Why should the grid lead of V.1 be screened?

See Page No.4 for diagram.

## Audio Frequency Amplifier (Transformer Coupling).

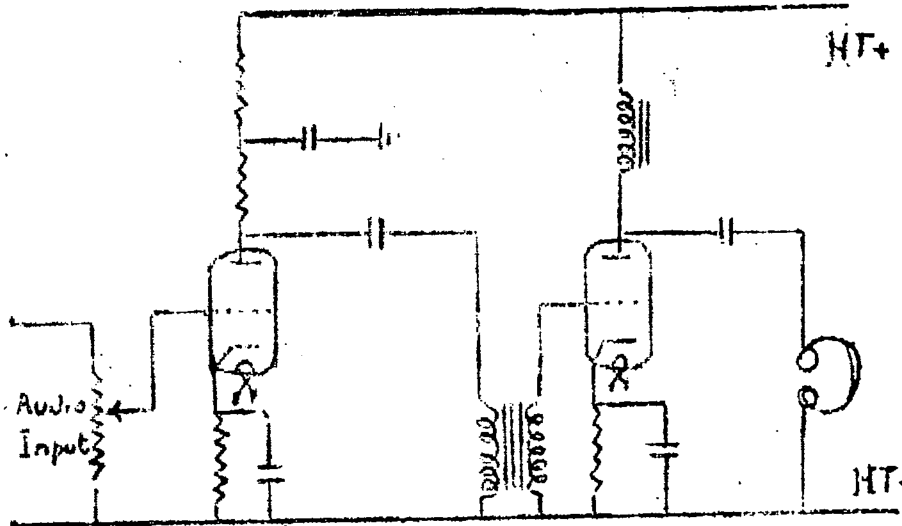



Fig 6

Rewire the amplifier to the above circuit. Why should the gain now be greater? Why should resistance capacity coupling be preferred in an audio frequency amplifier?

## Radio Frequency Amplifier.

Using a K.T.W.63 (V.R.100) and an R/F amplifier board, wire up the following board:-

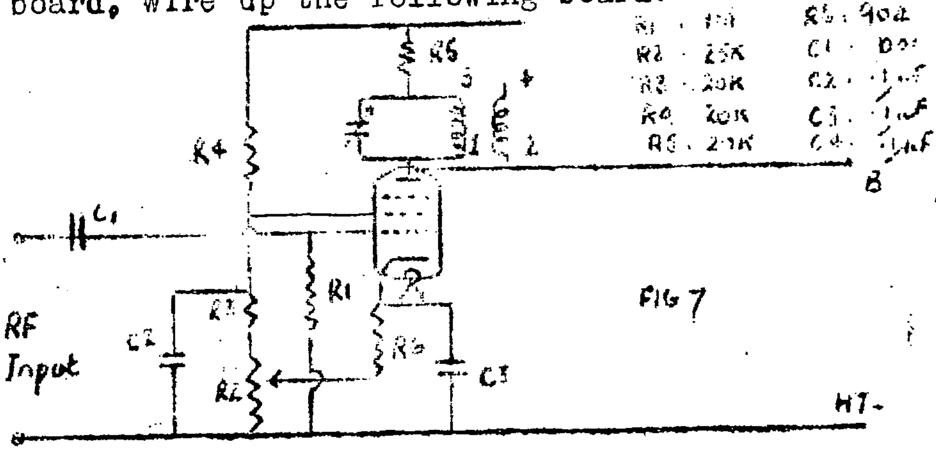



Fig 7

The anode coil to be used for medium frequency broadcast band is labled "An med f" and consists of two windings, the base connections from the underneath being as shown:-

See Page No.5 for diagram.......

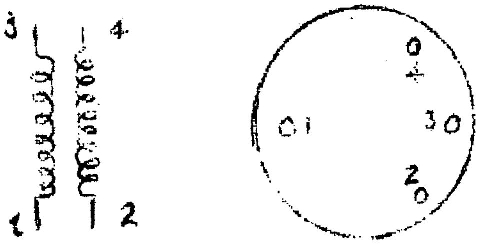



FIG 5

Connect up the above board with the aerial tuning unit. Detection board and audio amplifier to form a four stage straight receiver. The points C and D should be connected to the grid coil of the aerial tuning board at the points V and S shown in Fig:3. B should be taken to the grid condenser of the detector. The audio output of the detector should be fed to the audio amplifier. It will be observed that as the anode coil has two windings the second winding can be connected for use as an R/F using either tuned primary or secondary. At least the first of these possibilities should be tried. Why should the decoupling capacity in this stage be much smaller than in the A/F circuit? How is the gain of the vari-mu pentode controlled, and why is the resistance R.6 included in the circuit?

Instructions for the construction of Superheterodyne Receivers.

Simple Superheterodyne Receivers.

A simple superhet consisting of three stages frequency changer, I.F. amplifier and diode detector can be assembled by using the aerial tuning, frequency changing and second detector and output boards.

Using a triode hexode X66 (V.R.99 in R.1155) and a vari-mu pentode KTW.63 (V.R.100 in R.1155) wire up the frequency changer board as below. The boards have been designed so that the length of connecting leads will be a minimum. Why should this be necessary?

See diagram in Page No.6.........

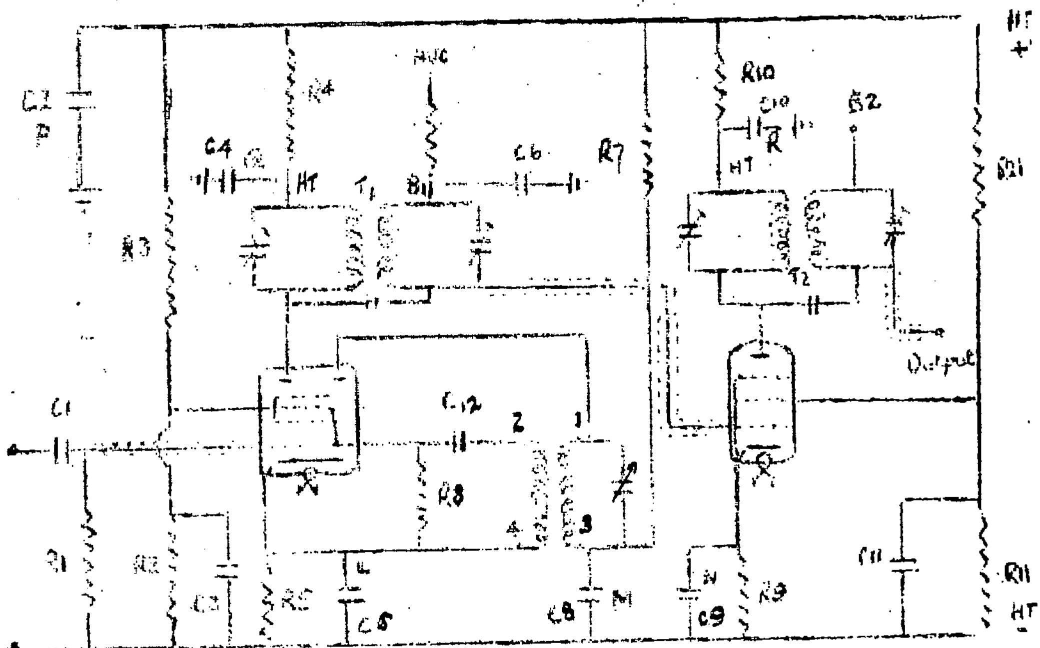


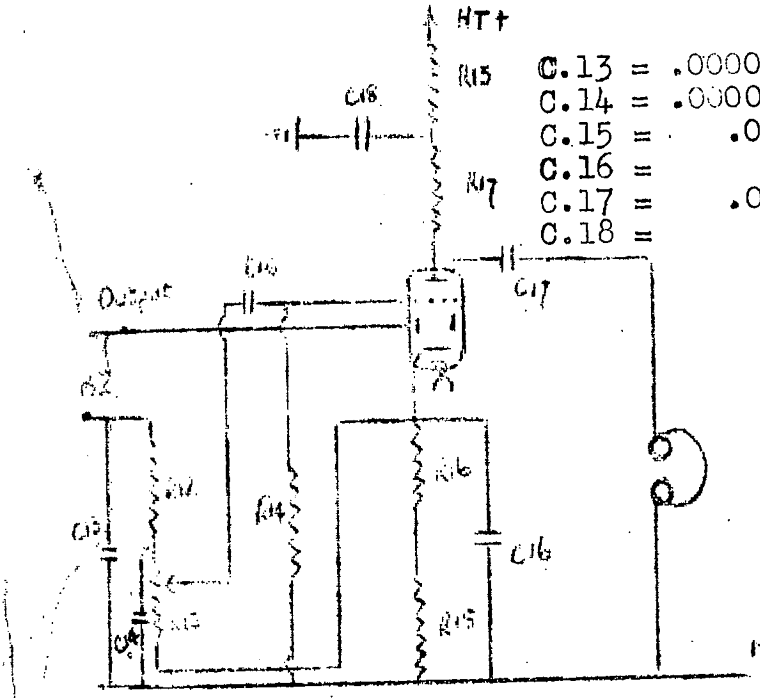
FIG 1

It should be noted that C2, C4 and C.10 are the three .5μF condensers labelled P,Q,R and located at the top of the board while C5, C8 and C9 are .5μF condensers labelled L,M,N and placed at the bottom of the board.

| | | | |
|---|---|---|---|
| R1 500K | R7 50K | C1 .0003μF | C7 .00015μF (var:) |
| R2 [illegible]0K | R8 [illegible]0K | C2 .5μF | C8 .5μF |
| R3 20K | R9 400 ohms to 1 K | C3 .01μF | C9 .5μF |
| | | | C.10 .5μF |
| R4 5K | R.10 5K | C4 .5μF | C.11 .01μF |
| R5 400 ohms | R.11 20K | C5 .5μF | C.12.0005 |
| R6 250K | R.21 50K | C6 .1μF | |

It will be seen that the I.F. transformers employ capacitative coupling whose coupling exceeds critical value at their resonant frequency of 500 Kc/s. Why should the transformers be designed with over critically coupled circuits?
What factors have lead to a choice of I.F. of 500 Kc/s. Note that three leads emerge from each I.F. transformer, anode of the associated valve being in each case already connected to the 'top' of the primary. The other end of the primary is labelled H.T., the 'top' end of the secondary is connected to the second lead at the top of the I.F. can, and the bottom of the secondary is labelled B1 B2. At the first I.F. the transformer T1 is connected via a .1μF condenser to ground. In the construction of this simple superhet this condenser must be shorted out. Why is this?

What purpose do C4, R4, C8, R8 and C.10 serve?
State briefly two possible conditions under which the triode section of the frequency changer would fail to oscillate. The points 1 and 2 should be connected to the grid coil and condenser located on aerial tuning board, (Fig:2) page 2. Using the components on the bottom left hand and right hand side top of the detector board wire up a double diode triode MHLD 6 (V.R. 101 in R.1155) to operate as second detector and output value as shown below



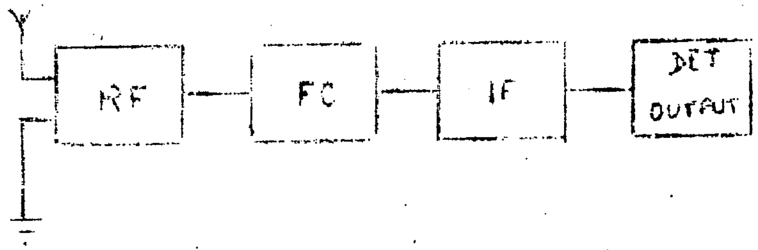

| | | | |
|---|---|---|---|
| C.13 = | .00005μF | R.12 = | 50K |
| C.14 = | .00005μF | R.13 = | 250K |
| C.15 = | .01μF | R.14 = | 500K |
| C.16 = | 4μF | R.15 = | 650 ohms |
| C.17 = | .01μF | R.16 = | 450 ohms |
| C.18 = | 4μF | R.17 = | 30K |
| | | R.18 = | 20K |

FIG 2

Connect one diode anode as shown to the output of the I.F. amplifier (top of secondary of last I.F. transformer) and R.12 to B.2 (bottom of secondary of last I.F. transformer).
Connect the power supplies and tune the receiver to a broadcast station.
What purpose do C.13, C.14 and R.12 serve?
What type of gain control is R.13?
When will the valve operate as a rectifier?
Under what conditions is the triode section of the valve operating, and what components serve to produce this condition?
What is the true audio load of the valve?

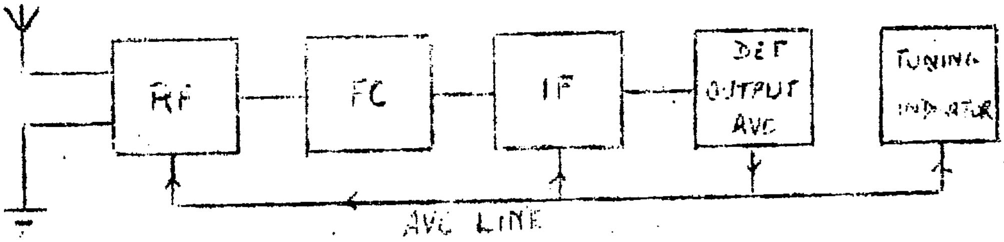
By varying the R.F. oscillator tuning compare the "selectivity" of your receiver with that obtained on the straight receivers constructed. What is the prime reason for the increased selectivity?

Construction of Superheterodyne Receiver having an R/F Amplifier Frequency Changer, I/F Amplifier Detector and Output Stages.




The best procedure is as follows:-
Disconnect the aerial tuning unit and connect the R/F amplifier board between aerial and frequency changer as in straight set employing an R/F amplifier stage. (Exp:e, page 3.). Turn up both gain controls to maximum and tune to an R/T transmission.
Adjust R/F oscillator, R/F amplifier anode and aerial tuning for maximum signal strength.
Under what conditions is maximum output obtained?
Why is this receiver more difficult to tune than a modern superhet?
Has it, however, any advantage over the modern commercial set?

Construction of Superheterodyne Receiver employing R/F, F/C, I/F Detector, Delayed AVC and Magic Eye Tuning Indicator.



To assemble this set the following is the best procedure:-

(a) Modify the detector circuit so as to employ the second diode section of the MHLD.6 to provide AVC as indicated below:

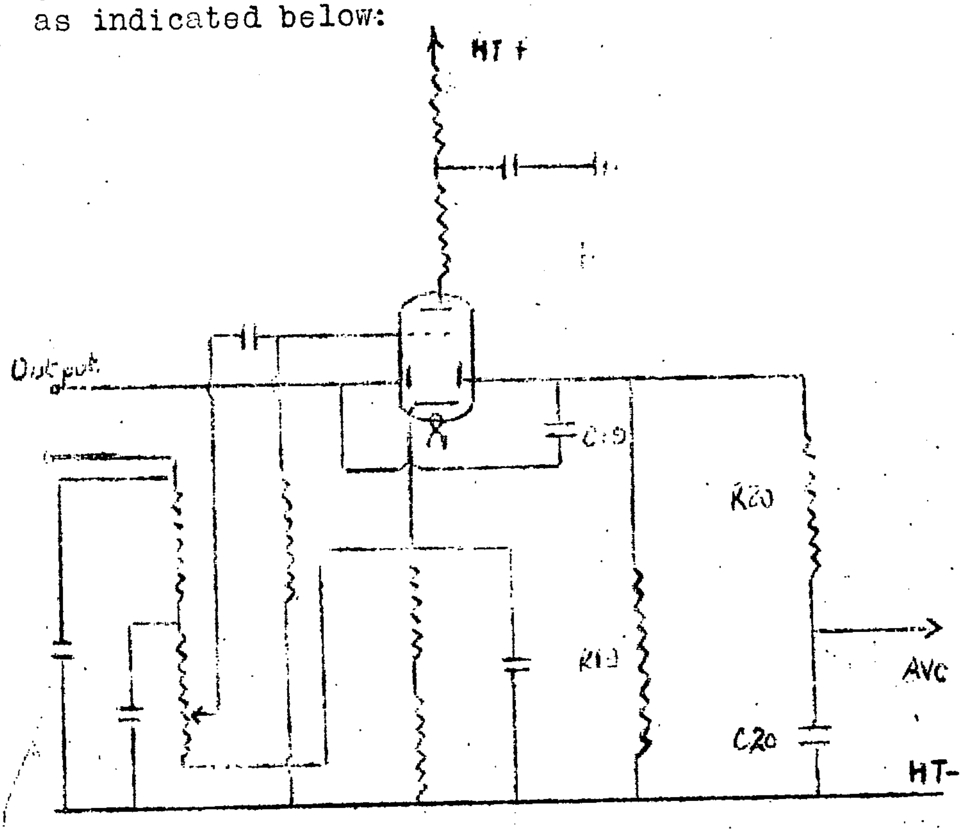



Figure No.3.

The components C1, C2, R1 and R2 are to be found at the top left hand corner of the detector board.

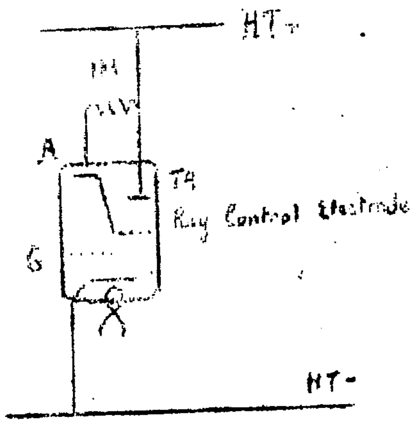
| | | | |
|---|---|---|---|
| C.19 - | .00005μF | R.19 | 1M ohms |
| C.20 - | .1μF | R.20 | 100K ohms |

How does the diode now provide delayed A.V.C? State briefly two advantages of using delayed AVC?

(b) The bottom of the secondary of the first I.F. transformer at B.1 should be disconnected directly from ground but leaving a connection through C.6 (Fig:1) to ground. AVC is then applied by connecting R.6, Fig:1, to C.20 (Fig:4).

(c) In the same way the grid resistance of the R.F. amplifier is connected to ground through .1μF condenser and the AVC line connected to the junction of the grid resistance and .1μF condenser.

(d) Using a cathode ray tuning indicator Y.63 (V.I. 103 in R.1155) wire up the tuning indicator to the following circuit:




The grid of the triode section of magic eye is connected to the A.V.C. reservoir condenser C.20 (Fig:4).

Having completed the wiring of the receiver put R/F gain control to three quarters maximum and audio gain control to maximum.
Adjust R/F oscillator, R/F amplifier and aerial tuning for maximum signal.
Watch the tuning indicator and swing the settings of each of the following controls in turn:
(1) A/F volume control.
(2) R/F oscillator tuning.
(3) R/F amplifier anode tuning.
(4) R/F amplifier gain control.
(5) Aerial tuning.
Account for what happens in each case.
Short the resistance R.6 Fig:1. What difference in performance occurs. Can you account for this change?

## Communication Exercises.

**Section A.**
Exercises in one way communication. Pupils working so that one team assembles a simple MOPA at a given frequency or COPA working into an artificial aerial whilst the receiving team assembles any of the simple receivers already outlined.
In this either R/T or C.W. communication can be effected.

**Section B.**
Exercises in two way communication. Pupils working in four teams. The first two teams assembled the trans-

mitter and receiver at one end of the intended line of communication whilst the other two teams assembled transmitter and receiver at the other end of line of communication. Either R/T or C.W. communication is possible.
A large variation of this system is possible thus the receiving station could be completed to search for the transmitting station and have to 'back tune' their transmitter to the receiver. Before replying each transmitter can be operated on a different frequency.

---

# GENERAL INSTRUCTIONS.

1. Before starting any experiment a circuit diagram must be drawn in your practical notebook.
2. Whenever a question is asked or current required an answer must be given in the notebook.
3. Whenever an H.T. or L.T. circuit is to be wired such connections must be most carefully checked for shorts before switching in power supplies.

# ALTERNATING CURRENT EXPERIMENTS.

1. Investigation of variation of inductive reactance with frequency.

The board provided contains a tapped air cored inductance of approximately 0.1 Henry and a 0.500 microammeter connected to a full scale deflection of 5mA.

Procedure.

Connect the whole of the inductance L and the meter in series, and apply the output from the audio generator G as in fig:1.

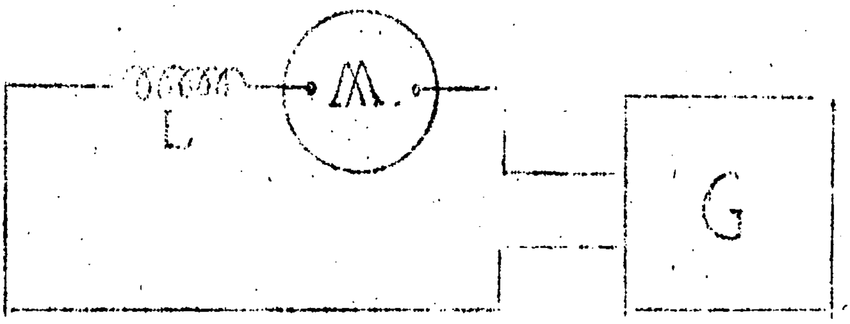



Fig.I.

The voltage from the generator can be varied in frequency from 1500 to 6000 cycles per second. As the output is not constant at all frequencies a potentiometer gain control and an output meter reading 0-150 (full scale deflection 3v A.C.) are fitted. Se the output of the generator to 1500 c/s and adjust the gain control until practically full scale deflection is obtained. Note the reading of the output meter: take the reading of current in the series circuit. Increase the frequency of the generator output by 250 c/s steps up to 4500 c/s, adjust the gain control to give the above value of output in each case and take corresponding readings of the current in the series circuit. Tabulate your readings as below:-

| | Frequency in c/s. | I Current (Meter reading) | |
|---|---|---|---|
| e.g. | 1500 | 500 | 1/I |
| | 1750 | | .002 |

Draw a graph showing the relationship between frequency and the reciprocal of circuit. Account for the general shape of the graph. Repeat the experiment using: 1/4 L 1/2 L and 3/4 L. For the success of these experiments it is essential that the laboratory instructor is asked to check the operation of the generator after each experiment.

2. Investigation of variation of capacitive reactance with frequency.

The board provided contains .025, .05 and .1µF condensers and a 5m A.A.C..

Procedure.

Connect the .05µf condenser in series with the A.C.meter and the variable frequency generator G.

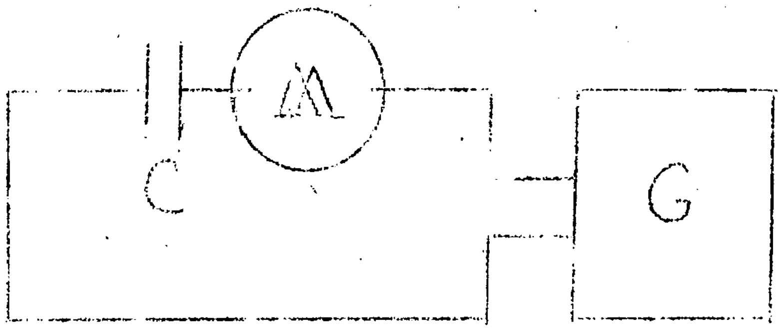



Fig. II.

Set the output of the generator to 4500 c/s and adjust the gain control so that practically a full scale reading is obtained. Note the reading of the output meter and the value of current in the series circuit. Decrease the frequency of the generator output by steps of 250 c/s, adjust the gain control to give the same value of output in each case, and take corresponding readings of current in the series circuit. Tabulate your results as below:

| Frequency c/s. | I current (Meter reading) | 1/I |
|---|---|---|
| 4500 c/s | 500 | .002 |

Draw a graph showing the relation between frequency and the reciprocal of current. Repeat the experiment using .025 µF condensers.

For the success of these experiments it is essential THAT the laboratory instructor is asked to check the operation of the generator after each experiment.

3. Series Resonance.

A. The board contains .025 .05 and .1 µF condensers with a tapped inductance of approximately 0.1 Henry and 0-5 mA A.C.meter calibrated 0-500.

Procedure.

Connect half the inductance in series with .05 µF condenser and the meter. Apply in series the output voltage of the generator.

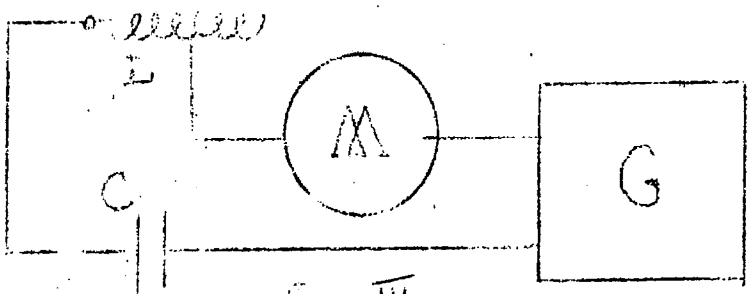


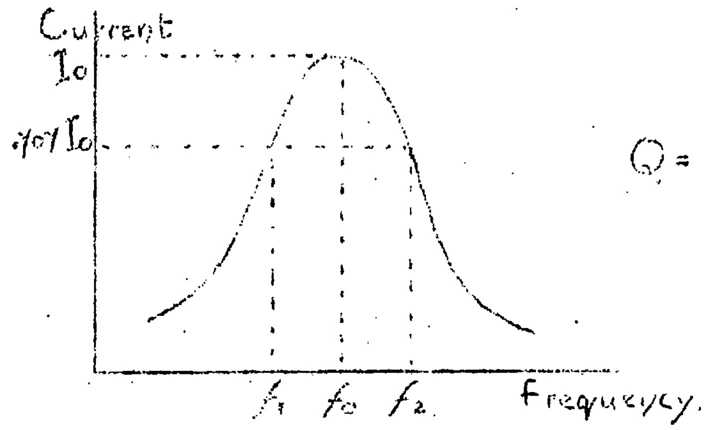

Fig. III.

Swing the generator frequency control over its range to find the resonant frequency of the series circuit. How will this be indicated? Adjust the output control of the generator so that the current in the series circuit is in the neighbourhood of full scale deflection. Note the reading of the output meter. Set the generator frequency control to 1 Kc/s and adjust the gain control so that the output meter gives the same indication as previously, and measure the current in the series circuit. Repeat this procedure taking readings at 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 and 4.5 Kc/s. Record your results as below:

| Frequency in Kc/s. | Value of circuit current. |
|---|---|
| 1 Kc/s | |
| 1.5 Kc/s | |

Plot a graph showing the above relations.
Repeat the above experiment.

B. Using a quarter of the inductance and .1µF condenser.
C. Using the whole of the inductance and .025 µF condenser.
D. Using half the inductance and .05 µF condenser as in experiment A but also include in the circuit a 80 ohm resistance. Plot graphs to show the the results of experiments B, C, and D using the same graph paper as for experiment A.
Account for these results, and in particular, the comparison between the results of experiments A and B.
E. A good estimate of the Q of a series circuit can be obtained by finding the three frequencies F0, Fi and F2 as illustrated below where f1 and f2 are the two frequencies either side of resonance when the current in the circuit .707 of its value at resonance.




$$Q = \frac{f_0}{f_2 - f_1}$$

fig. IV

Determine Q for the circuits of experiments A and B. Compare and account for the results.

4. Parallel Resonance.
A. The board contains .025 .05 and .1µF condensers with a tapped inductance of approximately 0.1 Henry and 0-5mA A.C.meter calibrated 0-500

Procedure.
Connect half the inductance in parallel with .05 µF condenser and apply the output of the generator measuring the make up current as indicated below:

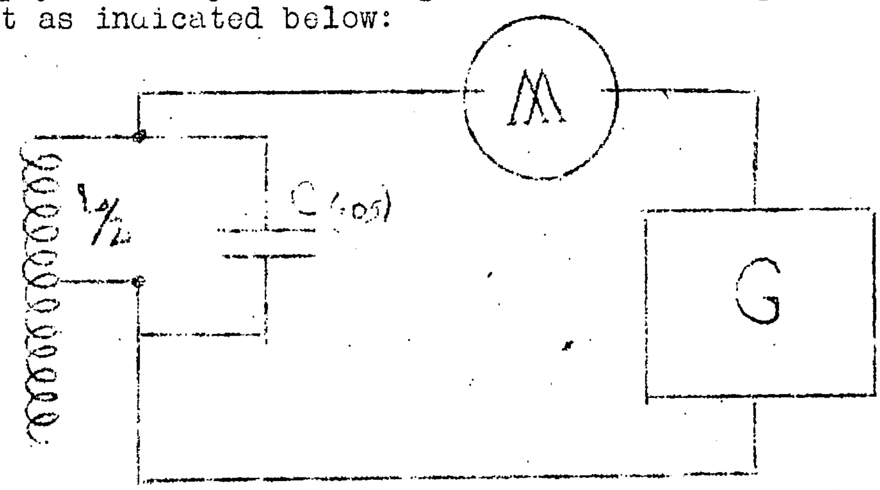



Fig. V

Swing the generator frequency control to 4:5 Kc/s and adjust the gain control of the generator to obtain a maximum measurable value of make up current. Note the reading of the generator output meter. Set the generator frequency control to 1 Kc/s and adjust the gain control of the generator so that the output meter gives the same indication as previously and measure the make up current to the parallel circuit. Repeat this procedure taking readings at 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 and 4.5 Kc/s.
Record your results as below

| Frequency in Kc/s. | Value of Make up Current. |
|---|---|
| 1 Kc/s | |
| 1.5 Kc/s | |

Plot a graph showing the above relation. Repeat the above experiment.

B. Using the whole of the inductance and .025 μF condenser.

C. Using half the inductance and .05 μF condenser as in experiment A but having a resistance of 1000 ohms across the circuit.

Plot graphs to show the results of experiments B and C on the same graph paper as thos of experiment A.

5. Coupled Circuits.

The board contains two of each of the following .025 .05 .1μF condensers and tapped inductance of approximately 0.1 Henry. A 0-5mA A.C. meter calibrated 0.500 is provided in addition. The two similar inductances are mounted vertically, and it is possible to vary the coupling between them by adjusting the position of the moveable one on a slider. Using half the inductance and .05 μF condenser check that in each case the two circuits formed have the same resonant frequency. Connect one circuit (to be called the primary) in series with the generator, and the other circuit (to be called the secondary) in series with the A.C.meter.

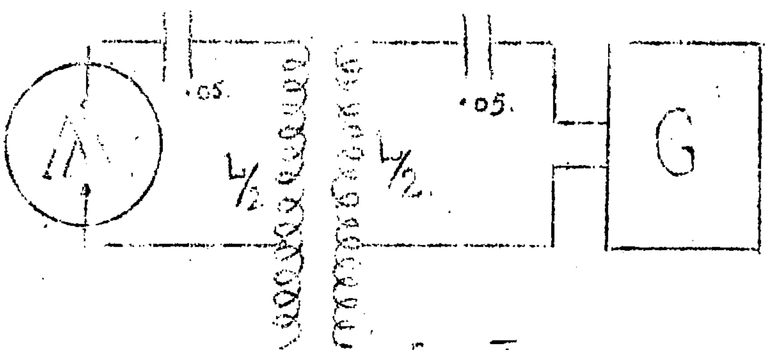



Fig VI.

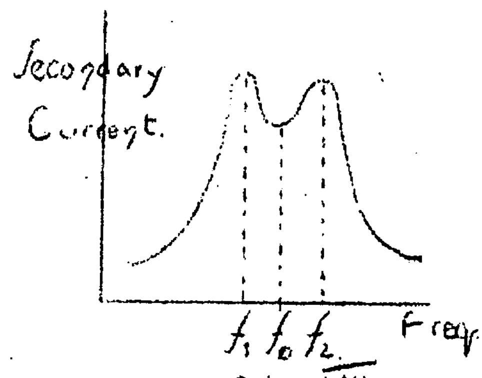



Fig. VII

Setting the generator at the resonance frequency of the two circuits, and starting with coils widely separated, move them together and note that the current in the secondary increases to a maximum then decreases. Why is this? Find the position of the moveable coil (note slider is graduated in inches) which gives maximum secondary current. The coils are then said to be critically coupled? AND THERE IS A MAXIMUM TRANSFERENCE OF ENERGY from the primary to the secondary in this position. Adjust the generator gain control to give approximately three quarters maximum possible secondary current at critical coupling and resonant freq:. Note the reading of the generator output meter. Keeping the coils in the critically coupled position adjust the generator frequency to 1 Kc/s and adjust the gain control of the generator to give the same output as above. Repeat the procedure at 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 and 4.5 Kc/s. Tabulate your readings as below:-

| Frequency in Kc/s. | Secondary Current. |
|---|---|

Plot a graph to show this relation.

Coupling Factor"K". Calculate this constant at maximum coupling by determing fo f1 f2, fo being the resonant frequency of the circuits and f1 and f2 the frequencies at which the secondary current is a maximum either side of resonance.

$$K = \frac{f_2 - f_1}{f_0}.$$

## GENERAL INSTRUCTIONS.

1. Before starting any experiment a circuit diagram must be drawn in your practical notebook.

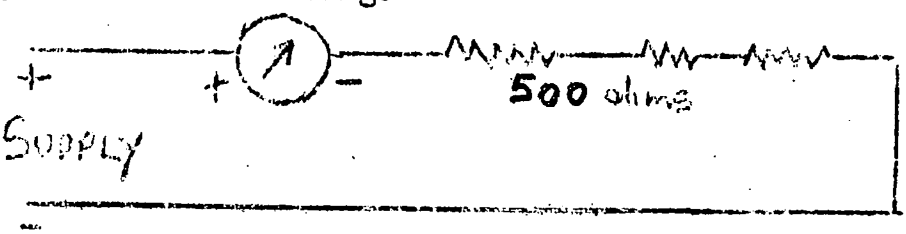
2. Whenever a question is asked an answer must be given in the notebook.

3. Whenever an H.T. or L.T. circuit is to be wired such connections must be checked most carefully for shorts before switching on power supplies.

## D.C. EXPERIMENTS.

### 1. CONSTRUCTION OF A 0 - 5 VOLTMETER.

The board contains a 0 - 5 milliammeter whose scale is graduated in 25 divisions.
Connect the meter in series with the nominal two volt supply (being careful of polarity) and with the 500 ohm resistor and such other resistors as are necessary to provide the appropriate scale reading.




Thus if the master voltmeter on the 2 volt supply registers 2.1 volts the resistances in the above meter circuit must be adjusted for a scale reading of 10.5 divisions when the meter will act as a 0 - 5 voltmeter.

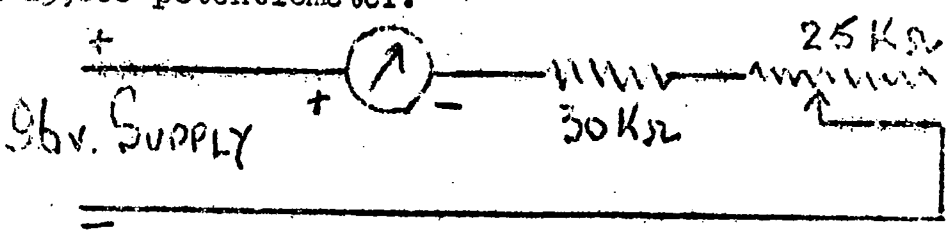
What will be the total resistance in the circuit? Account for discrepancies.

Use the instrument you have assembled to measure the voltage of the nominal 4 volt supply line.

How many ohms per volt is the instrument you have assembled?

### 2. CONSTRUCTION OF A 0 - 250 VOLTMETER.

Connect the meter in series with the nominal 96 volt supply (being careful of polarity and with 30,000 ohms fixed resistor and 25,000 potentiometer.



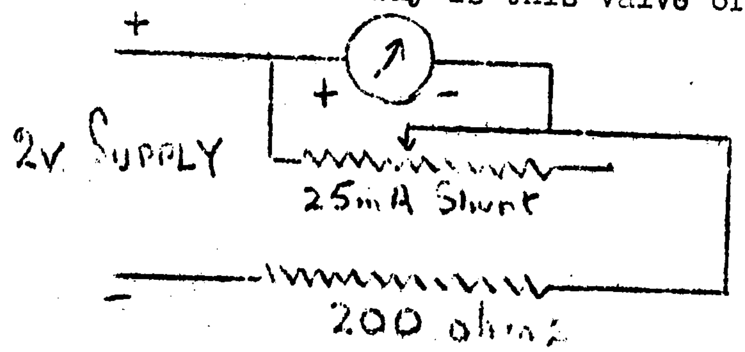

Adjust the latter for the appropriate reading.

Thus if the master voltmeter on the 96 volt line shows 105 volts the potentiometer will be adjusted for a reading of 10.5 scale divisions. The assembled instrument will then have a full scale reading of 250 volts.

Measure the voltages on the other lines comparing them with the master voltmeter readings.

3. CONSTRUCTION OF 0 - 25 MILLIAMMETER.

Connect the 25 mA adjustable shunt across the meter setting the shunt to minimum value.
Connect the shunted meter in series with the 2 volt supply and with a resistance of 200 ohms comprised of suitable fixed resistors on the board. Why is this valve of resistance used?

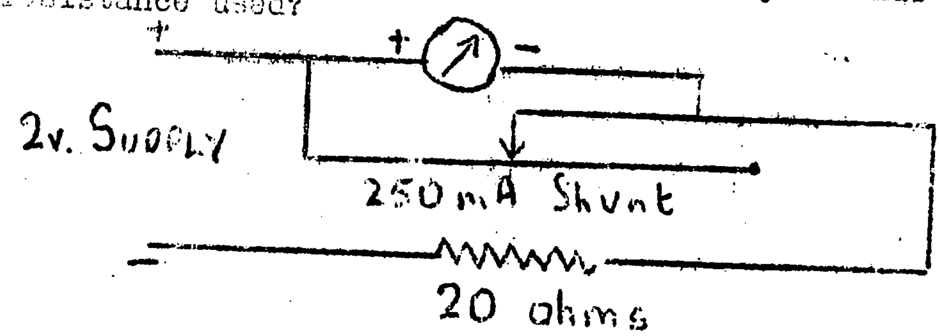



Adjust the shunt for a meter reading of ten divisisons. Do not open circuit the shunt. Why?

The 0 - 25 mA shunt consists of 29 inches of eureka wire ( 4 ohms per yard) wound with 19 inches on the former and 10 inches carrying the adjustable contact.
What is the calculated resistance of the meter movement?
Connect the 2 volt supply in series with the assembled 0 - 25 milliammeter and the unknown resistance X and then determine the value of the latter.

4. CONSTRUCTION OF A 0 - 250 MILLIAMMETER.

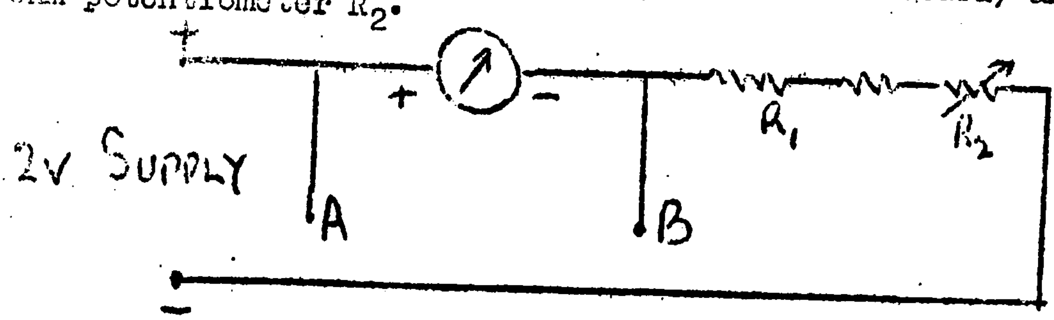
Connect the 0 - 250 mA shunt across the meter setting the shunt to minimum value.
Connect the shunted meter in series with the 2 volt supply and with a fixed resistance of 20 ohms. Why is this value of resistance used?




Adjust - do not open-circuit the shunt - for a meter reading of ten divisisons. Why is this done?
Connect the 2 volt supply in series with the assembled 0 - 250 milliammeter and the unknown resistance Y and thus determine the value of the resistance.

5. CONSTRUCTION OF A LOW RANGE OHMMETER.

Connect the meter in series with a resistance of 365 ohms R, (consisting of suitable fixed resistors on the board) and 100 ohm potentiometer $R_2$.



Adjust R2 for full scale meter reading. Call this value of current $I_1$.

Measure the unknown resistance Y by placing it across the meter at A and B.

If the new value of current is $I_2$

THEN $Y = \left(\frac{12}{I_1 - I_2}\right) M$

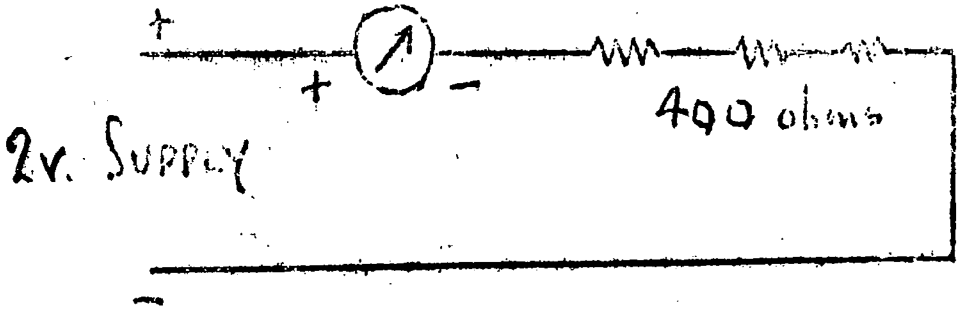
Where M is the meter resistance previously measured in experiment 3.

This result can be verified by assuming the total current through the circuit is unaltered when the meter is shunted. Under what conditions is this approximation justified?

Compare the value of Y with that obtained in experiment 4. Measure the unknown resistance "X" by the same method and compare its value with that obtained in experiment 3.

6. CONSTRUCTION OF A HIGH RANGE OHMMETER.

Connect the meter in series with at least 400 ohms (comprised of fixed resistors on the board) and the two volt supply.




Adjust the value of the total circuit resistance using the marked fixed resistors until the meter gives a full scale deflection. Call this value of current $I_3$ and the total circuit resistance R.

Measure the resistance Y on the board by including it in series with the above circuit.

If the new current reading is $I_4$

THEN $Y = \left(\frac{I_3 - I_4}{I_4}\right) R$

Compare this value of Y with those oreviously obtained verify the above formula.

Repeat the experiment determining the value of X.

How is the operation of the ohmmeter effected by any change in supply of voltage?

# CHAPTER 2.

## VALVE CHARACTERISTICS.

A. The Apparatus.

The apparatus provided for plotting valve characteristics consists of a four range milliammeter mounted on a board carrying different types of valve holders whose pins are brought out to appropriately numbered terminals.

The milliammeter is connected to a leaf switch so that on each of the four milliampere ranges viz. (1) 0-15 mA, (2) 0-30 mA, (3) 0-75 mA, (4) 0-150 mA a different shunt is employed.

What safety factor is introduced by using a wide leaf contact?

Always leave the meter switched to range 4.

B. General Instructions.

The H.T. and Bias Voltages are obtained from bench distribution boxes, each supplied by banks kf accumulators. These Lines are labelled with their nominal voltage, but in each case the actual voltage on a particular line may be obtained by switching the master meters at the control panels to the appropriate line.

The supplies to the boards are to be taken through the fuse-box on the bench, where provision exists for fusing seven lines, two G.B. negative, one G.B. positive, one H.T. negative, and three H.T. positive.

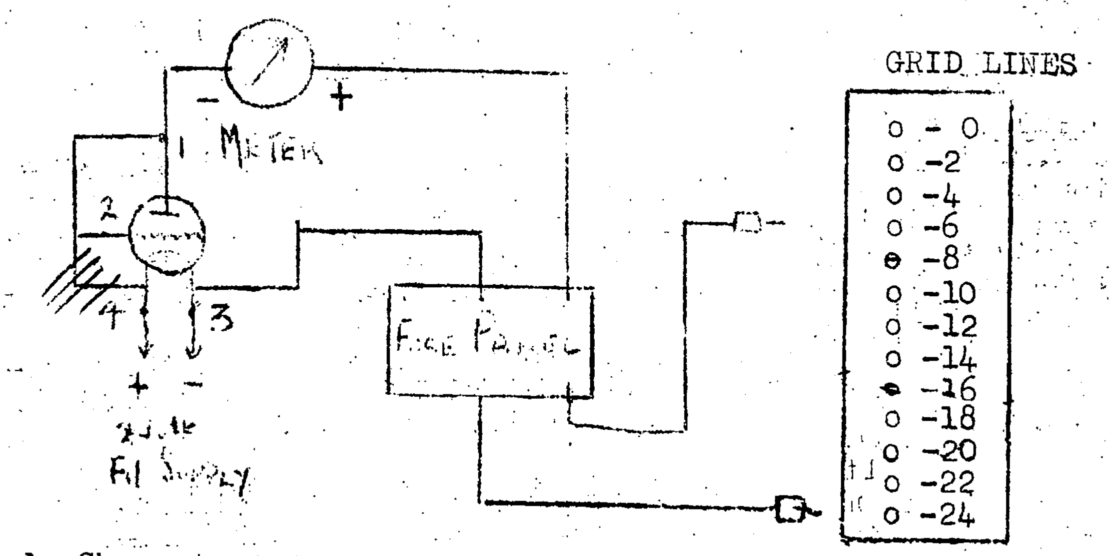
When plotting valve characteristics it is essential that the undermentioned steps be clearly understood and carefully followed:-

1. Before any voltages are applied the circuit wiring, especially the pin connections must be checked.
2. The correct filament heater voltage must be used and it must be ascertained as far as possible that the valve lights before the H.T. is applied. If any doubt exists, check the filament for continuity.
3. The meter must always be switched to range 4 initially AND THEN SWITCHED TO A LOWER RANGE AFTER TWO OR THREE MINUTES HAVE SERVED TO SHOW THAT THE NEW FULL SCALE DEFLECTION WILL NOT BE EXCEEDED.
   (Why is the time delay necessary?)
4. In all cases the H.T. negative and G.B. positive plugs must be inserted in the sockets labelled 0 on the H.T. and G.B. boxes respectively.
5. The following pages contain notes enabling you to plot complete anode and mutual characteristics of many of the commoner service type valves.
   Definite working conditions have been carefully stipulated but if time permits whole families of curves may be plotted provided maximum voltage and current ratings are not exceeded. All the voltages quoted in these notes are nominal line voltages. Actual readings can be obtained by reference to the control meters, and these values should be used when plotting all characteristics in laboratory notebooks.
6. Do not apply positive bias to receiver type values.

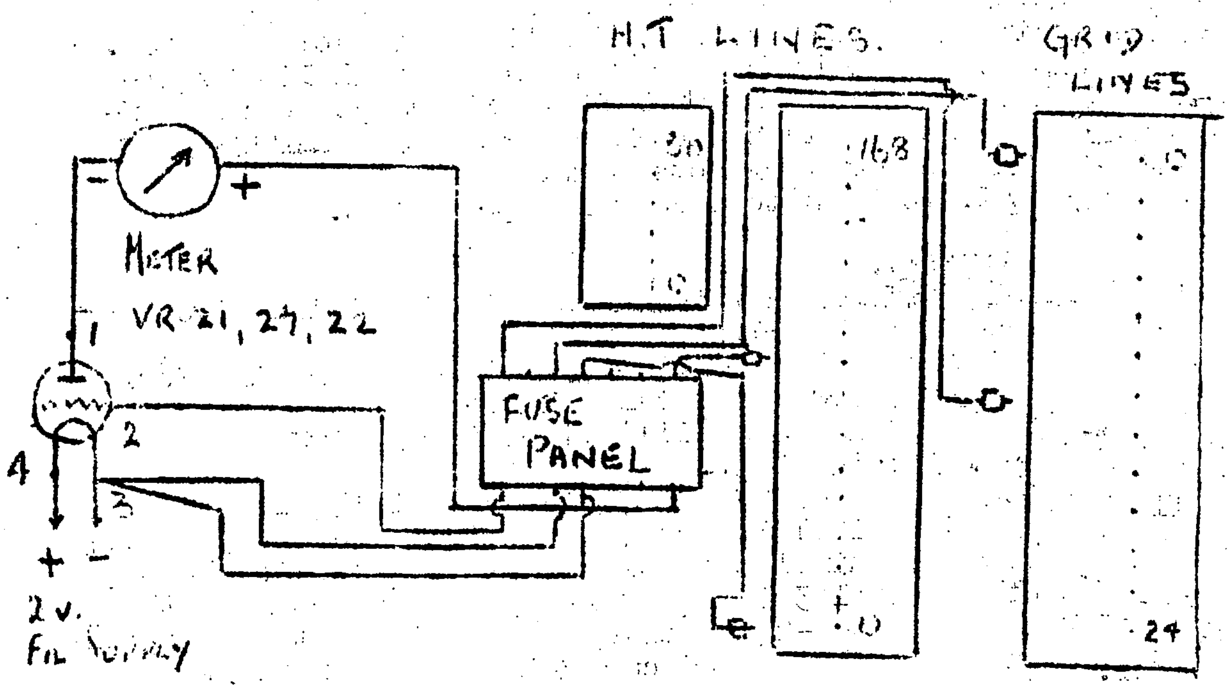
C. Diode Characteristics.

1. Insert a V.R.21 (Max Ia 10 mA) in the Standard British Five pin valve holder on the board.
   It will be noticed that the V.R.21 has a Standard British Four pin base whose pin numbers are given below:-
   (i) Anode. (ii) Control Grid. (iii) Filament Negative and Metallising. (iv) Filament.
   Strap the triode as a diode by connecting terminals 1 and 2 together. Connect terminal 3 to the negative side of the 2 volt filament supply and terminal 4 to the positive side of the same supply. Connect terminal 3 to the fuse panel and connect the othervside of the fuse to -24 volts on the Grid Voltage distribution box by means of a long lead carrying a wander plug.

Connect the meter as shown in the diagram and take another long lead carrying a wander plug to the Grid line -22 volts.
Take the reading of Ia from the meter.
Increase the voltage on the anode of the valve by two volt steps (i.e. next place meter leads at -20 volts, etc.) taking readings of Ia until a P.D. of 12 volts is applied to the valve.
Draw an Ia Va curve for the diode, plotting anode current readings against ACTUAL anode voltages.
Meter range 1 will be required for this experiment.




2. Triode Characteristics.
Read general instructions Section B.
A. Two-volt Types.
(i) V.R.21 - 2 volt directly heated triode - Standard British 4 pin base. Maximum Va 150 v, Maximum Ia 10 mA.
Anode Characteristics.
(a) Put Vg=0v by strapping terminals 2 and 3 together and increase Va by 6v steps from 0 to 36 volts and then by 12v steps from 30 to 120v.
(b) Put Vg=-2v as indicated in the diagram and repeat as for (a).
(c) Put Vg=-4v and repeat.
Plot these three anode characteristics.
Mutual Characteristics.
With Va=96v increase Vg from 0 by 2 steps to cut off value.
Repeat with Va=120v.
Plot these mutual characteristics and from them deduce Ra and Gm at Va=96v (actual) and Vg=0 (10K 1.4 mA/V).
Calculate μ.



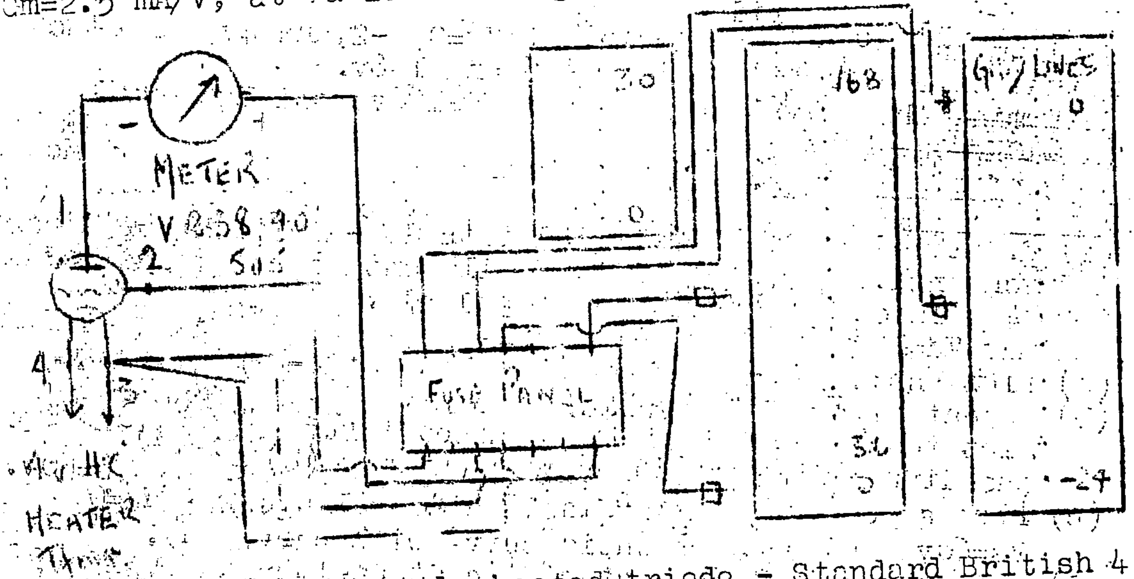
(ii) V.R.27 - especially selected V.R.21 - valve no longer available - repeat as for V.R.21.

(iii) V.R.22 - 2v directly heated triode - Standard British 4 pin base.
Maximum Va=150v, Maximum Ia=20mA.
Repeat as for C R.21 being careful not to exceed the above maximum value of Ia.
A.P.1186, Volume 1, Section 8, gives Ra=4K, Gm=4mA/V, at Va=100v, Vg=0.

(iv) V.T.20 - 2v directly heated triode. Maximum Va=150v, Maximum Ia=25mA. Standard British 4 pin base.
Plot the anode characteristics at Vg=0, Vg=-2v and Vg= -4v, and the mutual characteristics at Va=96v and Va=84v.
Determine the valve constants at Va=96v and Vg=0v.
(Ra=4K, Gm=2.25 mA/V).

B. Four Volt Types.

(i) V.R.38 - 4v indirectly heated triode - Standard British 5 pin base.
1. Anode. 2 Grid. 3 Heater. 4 Heater. 5 Cathode.
Maximum Va=250v, maximum Ia=30 mA.
Plot the anode characteristics of this valve at Vg=0, -2v and -4v, for those anode voltages which do not give excessive anode current, and mutual characteristics at Va=84v and 108v.
Determine the valve constants at Va=84v and Vg=0v. (Ra=6.5K, Gm=2.5 mA/V, at Va=100v and Vg=0v).




(ii) V.R.40 - 4v directly heated triode - Standard British 4 pin base. Maximum Va=400v, maximum Ia=125 mA.
N.B. As no centre tapped resistance is provided across the filament supply, join terminal 3 to the Bias source. Plot anode characteristics at Vg=0, -4v, and -8v being careful not to exceed the maximum anode current.
Plot the mutual characteristics at Va=60, 84 and 108v.
Determine the valve constants at Va=84v, Vg=0v.
(Ra=1.5K, Gm=7.0 mA/V, at Va=100v and Vg=0v).

(iii) V.R.505 - 4v indirectly heated triode - Standard British 5 pin base
1 Anode. 2 Grid. 3 Heater. 4 Heater. 5 Cathode.
Maximum Va=250v, maximum Ia=20 mA.
(a) Plot anode characteristics at Vg=0 and -2v.
(b) Plot the mutual characteristics at Va=12v, 132, 144 and 156v.
(c) Determine the valve constants at Va=120v, Vg=0,
(Ra=13.3K Gm=6mA/V)
What type of grid base does this valve possess?

C. Six Volt Types.

(i) V.T.105 - 6v indirectly heated triode - Standard British 5 pin base -
1 Anode. 2 Grid. 3 Heater. 4 Heater. 5 Cathode.
Maximum Va=250v, maximum Ia=30mA.

Plot anode charecteristics at Vg=0, -6, and -12v, and mutual characteristics at Va=132, and 144v.
Determine Ra and Gm at Va=144v and Vg= -6v. (Ra=4.5K, Gm=4.5 mA/V).

(ii) Triode Section of Double Diode Triode V.R.101 - 6.3v Heater. International Octal Base.
1 Blank. 2 Heater. 3 Triode Anode. 4 Diode Anode.1. 5 Diode Anode 2. 6 Blank. 7 Heater. 8 Cathode Top Cap Grid.
Maximum Va=250v maximum Ia=20mA.
Plot anode characteristics at Vg=0, -2, -4, and the mutual characteristics at Va=84 and 108v.
Determine the valve constants at Va=108v, Vg= -2v (Ra=4.5K, Gm=3 mA/V).

(iii) V.R.102 - 6.3v indirectly heated double triode - Octal base -
1 Blank. 2 Heater. 3 Anode 2. 4 Cathode 2. 5 Grid 1. 6 Anode 1. 7 Heater. 8 Cathode 1 Top Cap Grid 2.
Maximum Va=250v, maximum Ia=35mA. Use triode section 1 or 2.
Plot anode charectcristics at Vg= -2, -4, and -6v, and mutual characteristics at Va=84 and 108v.
Determine the constants of this valve at Va=108v, and Vg= -2v. (Ra=2.5K, Gm= 4mA/V).

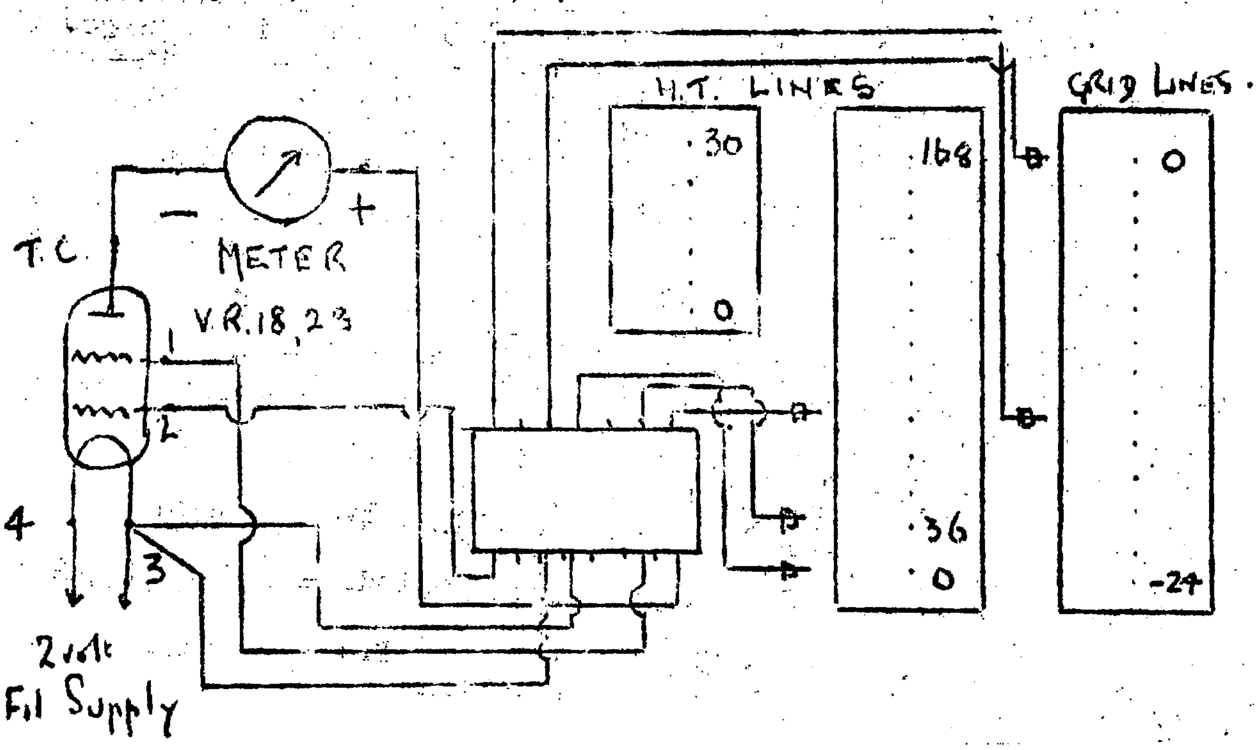
D. Thirteen Volt Triodes.

(i) V.R.109 - 13v indirectly heated triode - British 7 pin base -
1 Blank. 2 Blank. 3 Blank. 4 Heater. 5 Heater. 6 Cathode. 7 Anode, Top Cap Grid.
Maximum anode characteristics at Vg=0, -2,and 4v, and the mutual characteristics at Va=156 and 168v.
Determine the valve constants at Va=168v, and Vg= -2v. (Ra=10K, Gm= 4mA/V)

3. Screen Grid Valves.

A. Two Volt Types.

(i) V.R.18 - 2v directly heated tetrode - British 4 pin base -
1 Creen Grid. 2 Control Grid. 3 Filament Negative and Metallising. 4 Filament Positive, Top Cap Anode.
Maximum Va=120v, maximum Ia= 6 mA.
(a) Plot anode characteristics at Vg=0 and -2v, Vs=60v.
(b) Repeat with Vg=0v, Vs=48v.
Plot these characteristics, account for shapes, and for the difference between curves (a) and (b)
(c) Plot screen current against anode voltage for Vg=0, Vs=60v, and compare whtis curve with curve (a).
(d) Plot the mutual characteristic at Va=108v and Vs=60v.
Determine Ra and Gm at Va=108, Vs=60v and Vg=0v. (Ra=300k, Gm= 1.1 mA/V)

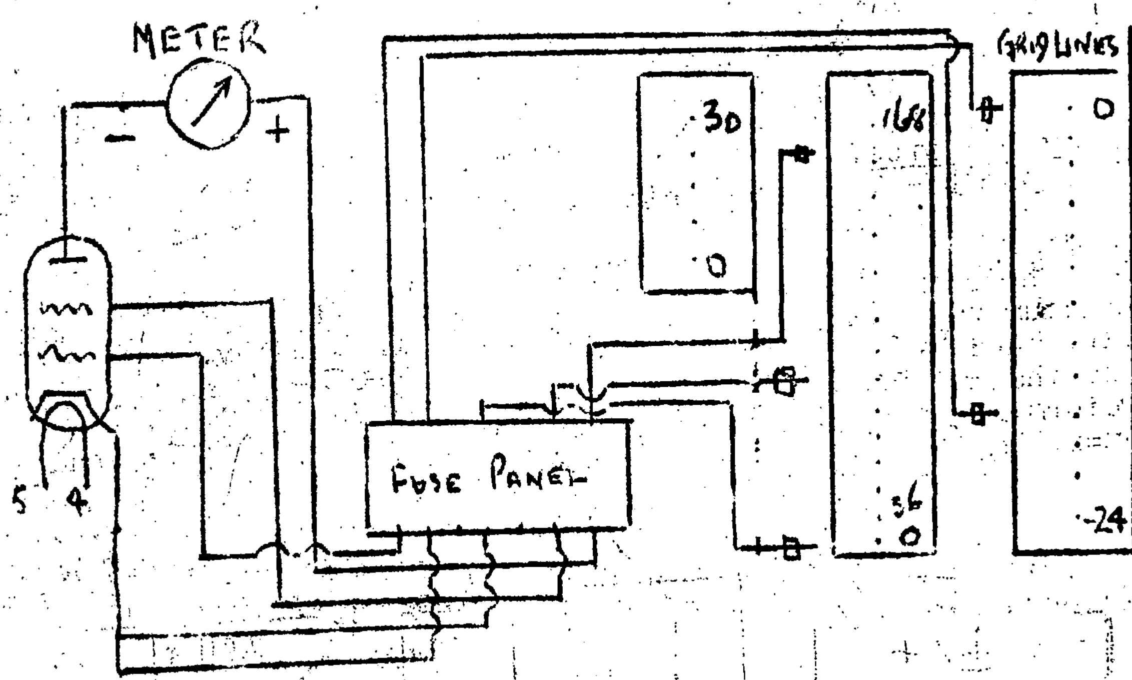


(ii) V.R.28 - 2v directly heated tetrode - British 4 pin base as for V.R.18.
Maximum Va=150v, maximum Vs=80v, maximum Ia=6mA.
Plot curves as for V.R.18. Plotting the mutual characteristics of both valves on the same graph. Account for any differences between these curves. (Ra=110K, Gm=1.6 mA/V).

(iii) V.R.118 - 2v directly heated beam tetrode - British 5 pin base -
1 Anode. 2 Control Grid. 3 Filament Negative. 4 Filament Positive. 5 Screen.
Maximum Va=150v, maximum Ia=20 mA, maximum Vs=150v.
Plot anode characteristics at Vg=0, -2 -4v, with Vs=96v, and mutual characteristic with Va=96v, Vs=96v.
Plot the screen characteristic with Vg= -2v and Vs=96v.
Add the ordinates of this characteristic to those of the anode characteristic for Vg= -2v and Vs=96v, hence obtaining an Ia + Is with Va graph.
Determine Ra and Gm for this valve at Va=Vs=96v and Vg=0v. (Gm=2.5 mA/V).

B. Four Volt Types.

(i) V.T. 75A - 4v indirectly heated tetrode-anode dissipation 25 watts - British 7 pin base -
1 Blank. 2 Control Grid. 3 Blank. 4 Heater. 5 Heater. 6 Cathode. 7 Screen, Top Cap Anode.
Maximum Va=400v, maximum Vs=300v, maximum Ia=100mA.
Plot anode characteristics with Vs=96v, Vg=0, -6, -12v, and mutual characteristics with Vs=96v, Va=120 and 168v.
Determine Ra and Gm at Va=168v, Vs=96v and Vg=0v.



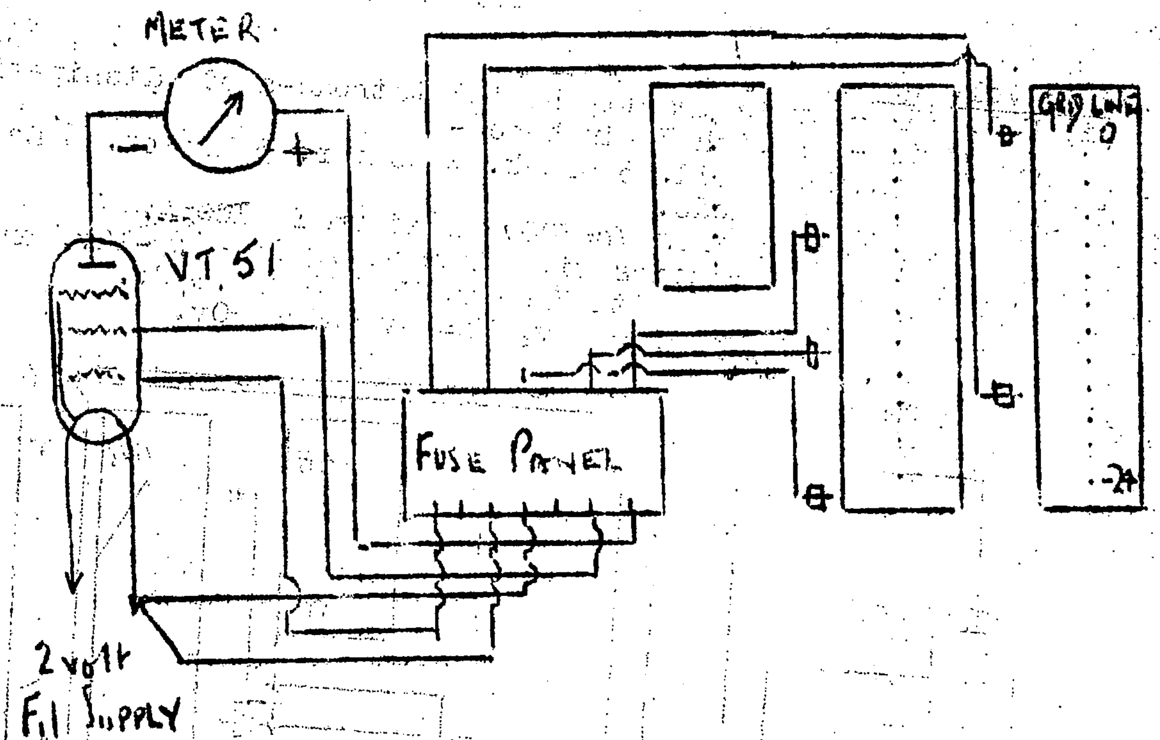

C. Sic Volt Types.

(i) V.T.60 - 6.3v indirectly heated beam tetrode - anode dissipation 25 watts - American Medium 5 pin base.
1 Heater. 2 Screen. 3 Control Grid. 4 Cathode. 5 Heater, Top Cap Anode.
Maximum Va=600v, maximum Vs=300v, maximum Ia=70mA. Be careful not to exceed the maximum anode current.
(a) Plot anode characteristics with Vs=72v, Vg=0, -4, and 10v.
(b) Repeat with Vs=120v, and Vg=10v.
(c) Plot the mutual characteristics for Va=96, and 168v and Vs=72v.
(d) Determine Ra and Gm with Va=168v, Vs=72v, Vg=0v.

4. Pentode Valves.

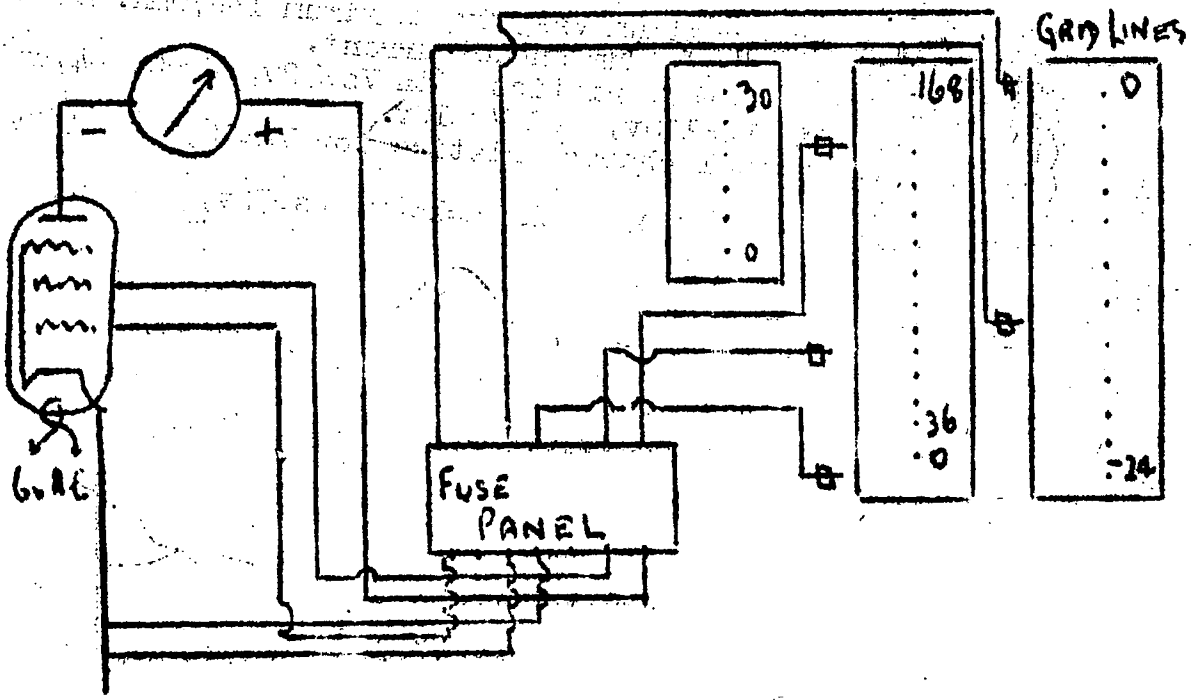
A. Two Volt Types.

(i) V.T.51 - 2v directly heated pentode - British 5 pin base.
1 Anode. 2 Control Grid. 3 Filament Negative and Suppressor Grid. 4 Filament Positive. 5 Screen.
Maximum Va=Vg=150v.
Plot anode characteristics with Vs=72v, Va=0, -2, -4v, and mutual characteristics at Vs=72v and Va=72 and 96v.
Determine Ra and Gm of this valve at Va=Vs=72v, and Vg=0v, (Gm=2.5mA/V at Va=Vs=100v, and Vg=0v).




B. Six Volt Types.

(ii) V.T.52 - 6.3v indirectly heated output pentode - International Octal Base.
1 Blank. 2 Heater. 3 Anode. 4 Screen. 5 Blank. 6 No Pin. 7 Heater 8 Cathode and Suppressor Grid, Top Cap Control Grid.
Maximum Va=300v, maximum Ia=40mA, maximum Vs=250v.
Plot anode characteristics at Vs=96v, Vg=0, -8, and 16v, and the mutual characteristic at Va=Vs=96v.
Determine Ra and Gm at Va=Vs=96v, and Vg= -8v, (Ra=70K and Gm=2.85mA/V at Va=Vs=250v, and Vg= -18.5v)



(iii) V.R.53 - 6.3v indirectly heated vari-mu pentode - International Octal Base.
1 Metallising. 2 Heater. 3 Anode. 4 Screen. 5 Suppressor Grid. 6 No Pin. 7 Heater. 8 Cathode, Top Cap Control Grid.
Maximum Va=Vs=300v, maximum Ia=16mA.
N.B.Connect Suppressor Grid to Cathode.
Plot anode characteristics with Vs=84v, Vg=0, -4, and -8v, and the mutual characteristic with Va=Vs=84v.
Determine Ra and Gm for this valve at Va=Vs=84v, and Vg=0v. (Ra=125K, Gm=2.2mA/V at Va=250v, Vs=100v and Vg= -2.5v)

(iv) V.R.91 - 6.3v indirectly heated pentode - British 9 Pin Loctal Base
1 Heater. 2 Screen. 3 Anode. 4 Suppressor Grid. 5 Internal Shield. 6 Cathode. 7 Control Grid. 8 Internal Shield. 9 Heater.
Maximum Va=Vs=300v, maximum Ia=25mA.
(a) Plot the anode characteristics with Vs=120v, Vg=0, and -2v, and the mutual characteristics with Va=168v, Vs=120v, and Va=Vs=168v, connecting Suppressor Grid and Internal Shields to Cathode.
(b) Repeat the mutual characteristics but connecting the Suppressor Grid to the Control Grid (Shields still to Cathode)
(c) Compare the mutual characteristics obtained in (a) and (b) accounting for any differences and determine Ra and Gm for this valve at Va=168v, Vs=120v, abd Vg=0v. (Gm=6.5 mA/V at Va=Vs=250v, Vg= -2v)

(v) V.R.100 - 6.3v indirectly heated vari-mu pentode - International Octal Base.
1 Blank. 2 Heater. 3 Anode. 4 Screen. 5 Shield. 6 No Pin. 7 Heater. 8 Cathode, Top Cap Control Grid.
Maximum Va=250v, maximum Vs=100v, maximum Ia=15mA.
Plot anode characteristics at Vs=84v, Vg=0, -4v -8v, and the mutual characteristics at Va=Vs=84v.
Determine Ra and Gm at Va=Vs=84v and Vg= -4v. (Gm=2.7 mA/V at Va=250v Vs=80v, and Vg= -4v).

(vi) V.R.106 - 13v indirectly heated vari-mu pentode - British 7 pin base.
1 Blank. 2 Anode. 3 Suppressor Grid. 4 Heater. 5 Heater. 6 Cathode. 7 Screen, Top Cap Control Grid.
Plot anode characteristics at Vs=84v, Vg=0, -4, -8, and the mutual characteristic at Va=Vs=84v, connecting Suppressor Grid to Cathode.
Determine the Ra and Gm of this valve at Va=Vs=84v, and Vg= -4v. (Ra=600K, Gm=1.65mA/V at Va=250v, Vs=125v, Vg= -3v).

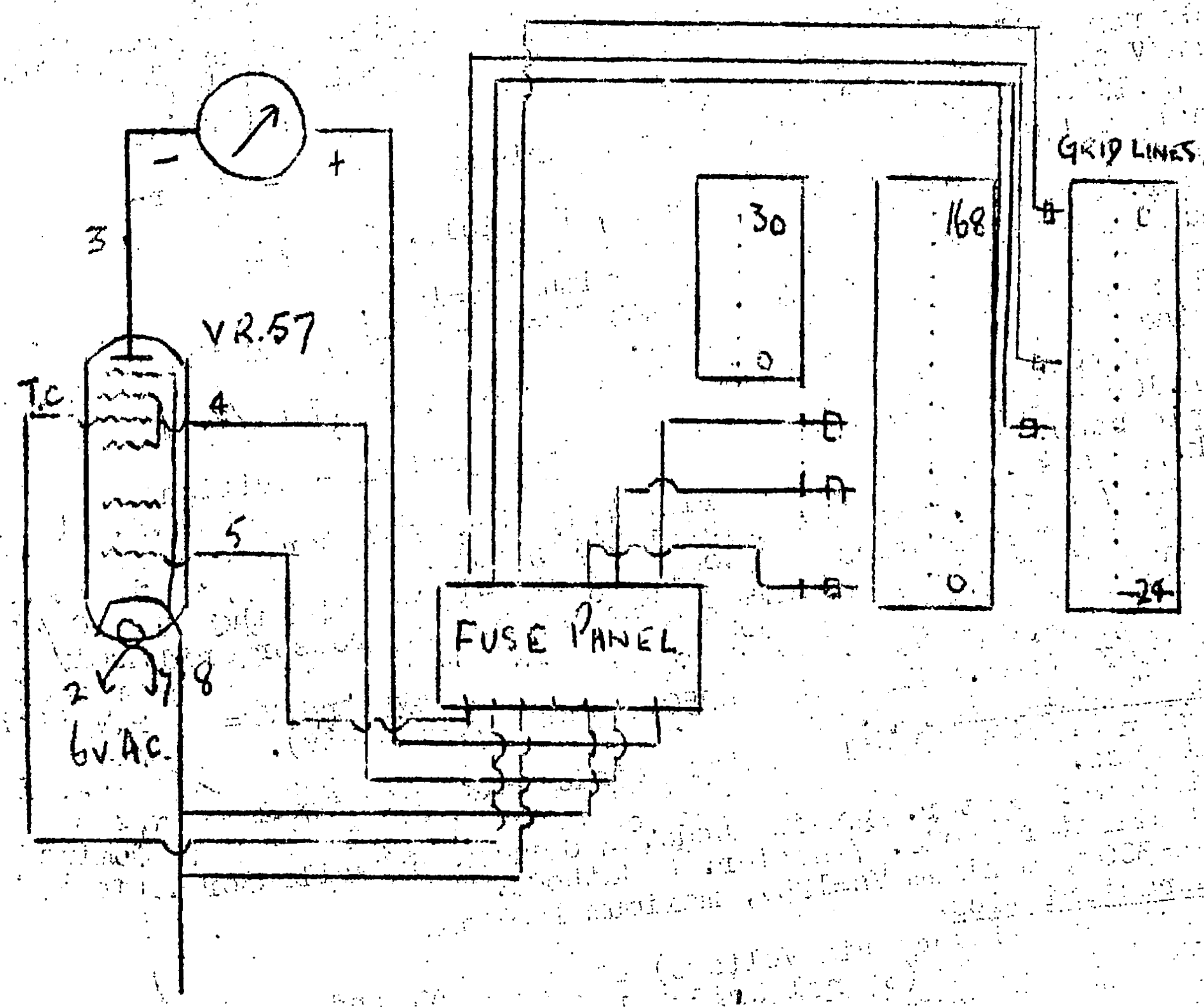
5. Frequency Changing Valves.

(i) V.R.57 - 6.3v indirectly heated octode - International Octal Base.
1 Metallising. 2 Heater. 3 Main Anode. 4 Screen. 5 Oscillator Grid. 6 Oscillator Anode. 7 Heater. 8 Cathode.
Maximum Va=300v, maximum Vs=125v, maximum Ia=12mA.
Mutual Characteristics.
(a) With Vgo (Oscillator Grid Voltage) =0, Va=168v, and Vg=72v, increase Vg (Signal Grid Voltage) by two volt steps to cut off value, noting anode current at each step.
(b) Repeat with Vgo= -2, -4, -6, -8, and 10v.
(c) Plot these mutual characteristics, and assuming a fixed bias of -6v is applied to the Signal Grid when the voltages on the main anode and screen are 168v and 72v, respectively, indicate from the curves the operation of frequency changing.
What type of characteristic has the signal grid?
What use is made of this characteristic in receivers?

See Page No. 8 for diagram.................

(ii) V.R.99 and V.R.99A - 6.3v indirectly heated triode-hexode - International Octal Base.
1 Blank. 2 Heater. 3 Main Anode. 4 Screen. 5 Oscillator Grid. 6. Oscillator Anode. 7 Heater. 8 Cathode, Top Cap Control Grid. Maximum Va=250v, maximum Vs=100v, maximum Ia=12mA.
Repeat as for V.R.57.

(iii) V.R.107 - 13v indirectly heated heptode - British 7 pin base.
1 Oscillator Anode. 2 Oscillator Grid. 3 Screen. 4 Heater. 5 Heater. 6 Cathode. 7 Main Anode, Top Cap Control Grid. Maximum Va=250v, maximum Vs=100v, maximum Ia=15mA.
Repeat as for V.R.57.



# UNIVERSAL VALVE CHARACTERISTIC DEMONSTRATOR.

## CONTENTS.

# I N T R O D U C T I O N.

This piece of equipment has been designed so that either mutual or anode characteristics of valves under selected conditions can be shown on the cathode ray oscilloscope.

## GENERAL INSTRUCTIONS.

1. The electrode switches, "Anode", "Grid 1", "Grid 2", "Grid 3" and "Cathode", must always be in the "off" position when the equipment is switched on; unless they are set up for a specific valve, as per the Data Sheet, in which case that valve only must be inserted in its appropriate holder.

2. The Electrode Switches must on no account be rotated unless the U.V.C.D. is switched off.

3. The equipment must be used only with a specially modified Cossor Double Beam Oscilloscope, which will be labelled accordingly, otherwise an inverted or reversed trace may result, and also it will be impossible to suppress the fly-back, which will give rise to "looped" characteristics.

4. The screened leads provided must be used for connection to the oscilloscope.

5. WARNING.
WHEN THE MASTER SWITCH IS AT Ia/Vg THERE IS A HIGH VOLTAGE BETWEEN THE "E" TERMINAL OF THE U.V.C.D. AND CHASSIS.
BESIDES OBSERVING PRECAUTIONS IN HANDLING THE SCREENED LEADS CARE MUST BE TAKEN TO SEE THAT THE SCREENING DOES NOT COME INTO CONTACT WITH THE CHASSIS, OR THE U.V.C.D. MAY BE DAMAGED.

ON THE Ia/Vg POSITION THERE IS A DIFFERENCE OF ABOUT 250V BETWEEN THE CHASSIS OF THE U.V.C.D. AND THAT OF THE OSCILLOSCOPE.

6. OVERLOAD CIRCUIT.
This will operate and cut off all supplies if the U.V.C.D. is overloaded in any way.
"Chatter" of the overload relay will indicate that the load is becoming excessive.

To Re-set. SWITCH OFF THE U.V.C.D. and remove the overload. On switching on again the equipment will be working normally.
If the U.V.C.D. is not switched off the overload circuit breaker will remain in operation.

Should the Overload Circuit Breaker operate while a valve is being demonstrated, switch off and either increase the bias or reduce the screen voltage before switching on again.

# "SETTING-UP".

BEFORE SWITCHING ON THE U.C.V.D.:-

Plug valve in appropriate socket and from the data provided set the Electrode Switches to the correct positions. Ensure that the filament voltage setting is correct, and for International Octal valves see that the filament pin selector switch is in the correct position (e.g. 2/7). Make sure that there is some bias applied to the valve.
The U.V.C.D. may then be safely switched on.

Oscilloscope Settings.
The C.R.O. Time Base is not used. This is effected by placing the Time Base coarse control in position 1. The other Time Base controls on the C.R.O. will then not affect the trace produced by the U.V.C.D.
Other controls not operative:- SYNC. Y2 AMP.

N.B. When the U.V.C.D. is "off" the spot will normally be stationary on the screen. To ensure that the screen is not burnt, therefore, whenever the U.V.C.D. is switched off the Brilliance control should be turned down to black out the spot, or the Time Base should be temporarily switched on.

MASTER SWITCH. Set to "AMP. Y1, Y2".

X SHIFT, Y1 SHIFT, Y1 AMP, FOCUS: Set as required.
(Y1 AMP setting should normally be left at zero for best results).

BRILLIANCE. This control should be rotated in an anti-clockwise direction just sufficiently to entirely eliminate the fly-back trace. The trace obtained should then be clearly visible in a semi-darkened room.
Y2 SHIFT. The Y2 trace may be used to indicate the X axis. In this case the A2 terminal on the C.R.O. should be connected to the "E" terminal.
It must be remembered that as "double ended" amplifiers are used in the C.R.O. any adjustment of the Y1 AMP will alter the position of the X axis, and when using the Y2 trace for this purpose care must therefore be taken not to introduce unnecessary confusion to the pupils because of this phenomenon.
Normally the Y2 trace should be set off the screen.

---

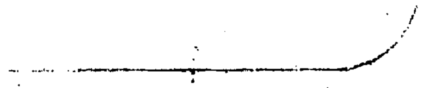
## Ia/Vg.

Having followed the "Setting-up" instructions, switch on, with the selector switch set to Ia/Vg.
Set the Anode Voltage Control to maximum.
The Screen Voltage control will have no effect on triodes. For screened grid or pentode valves set the screen voltages to the optimum voltage indicated in the data sheet.
Set the Bias Control to give the approx: voltage indicated in the data sheet, and the Grid Drive Control to a slightly higher voltage.
Unless special effects are to be shown the Suppressor Grid Switch should be left at "C" (Cathode).
Adjust G.B., GRID DRIVE, and Y1 AMP for best results.
The effect on the Characteristic of altering the Screen and Anode potentials can now be observed.
Once the optimum settings for the G.B. Control, the Grid Drive Control and the Y1 AMP have been determined these should not be altered unless it is desired to demonstrate special effects.
Grid current should not be allowed to flow.

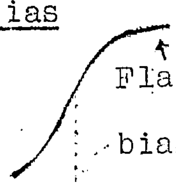
"SETTING-UP"

Ia/Vg continued.

Effect of too much bias.

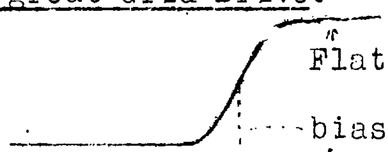



Effect of too little bias

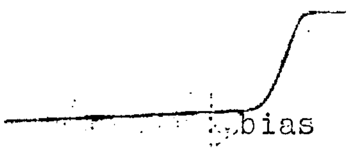



Effect of too little Grid Drive.


Effect of too great Grid Drive.

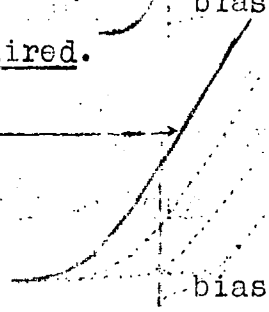



Combined effect of too much G.B. and Grid Drive.




Effect of too much Y1 AMP gain.


Characteristics Required.




Ia/Va.

When switching from Ia/Vg to Ia/Va, or vice versa, switch off.

Observe "Setting-up" instructions and switch on, with selector switch at Ia/Va and Anode Volts at MIN. (pos. 1).

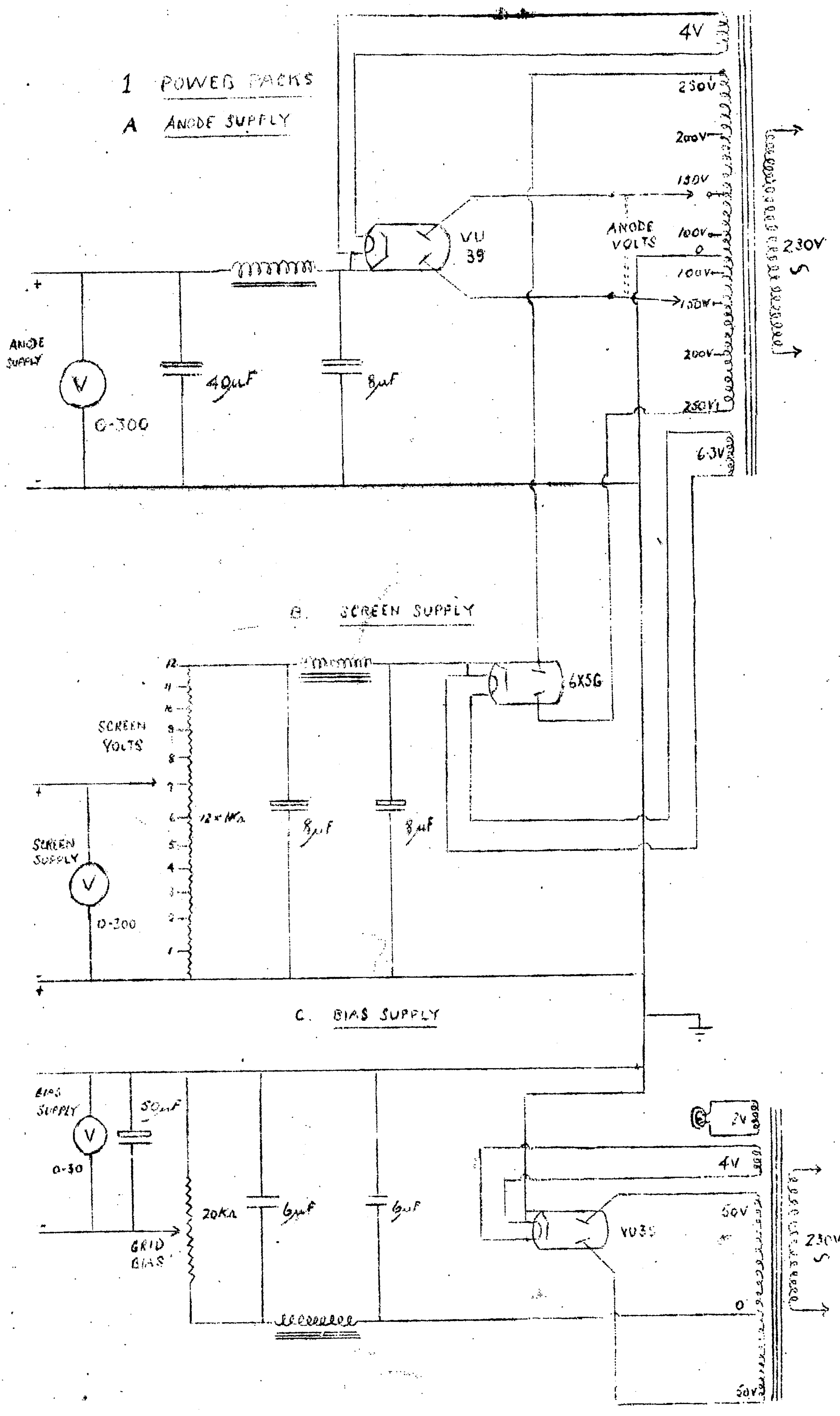
The Grid Drive Control is not in circuit.

Set Y1 AMP for best results, and then do not alter.

The Suppressor Grid switch should be left at "C" unless special effects are required.

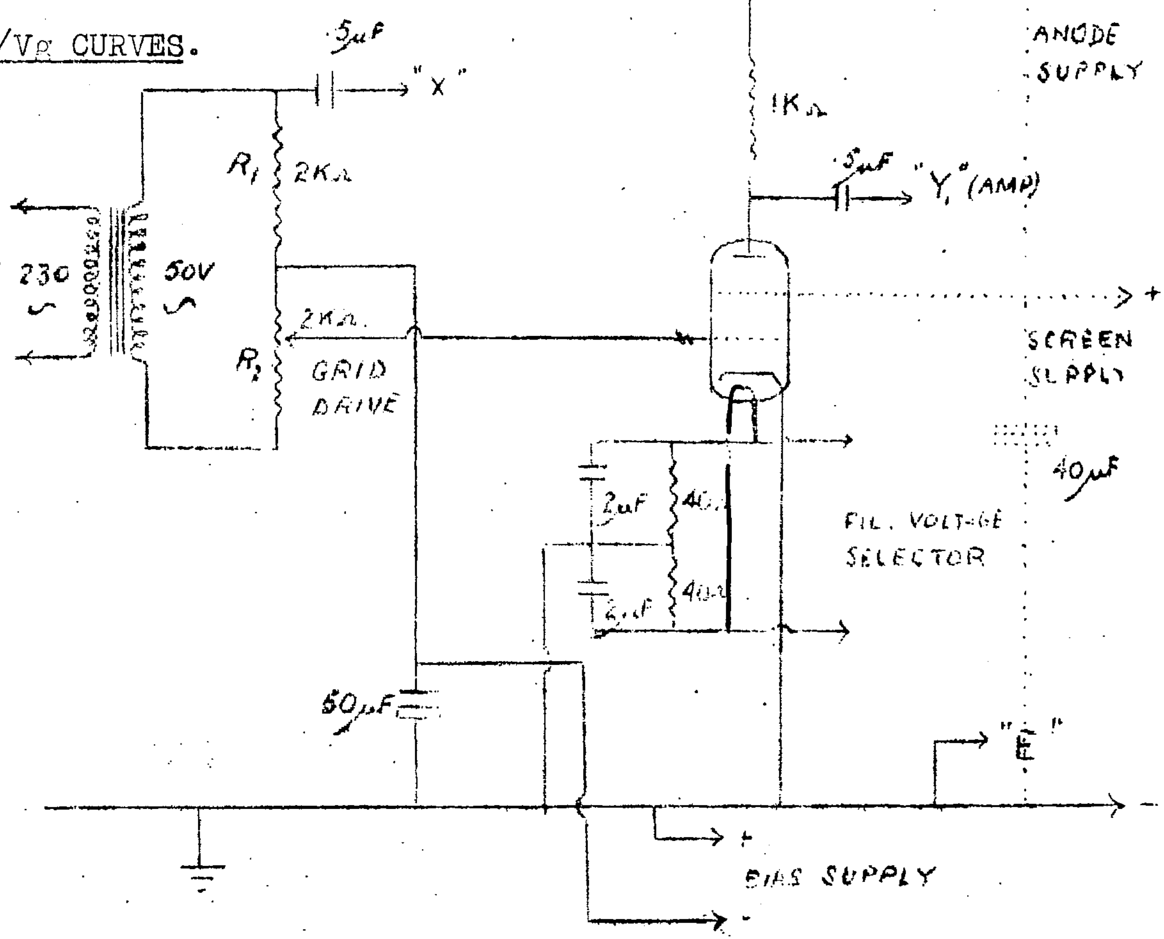
The effect on the Characteristic of altering the screen and grid potentials can now be shown.

SEE ALSO "INSTRUCTIONAL OPERATION".


1 POWER PACKS
A ANODE SUPPLY
4V
250V
200V
150V
100V
0
100V
150V
200V
250V
6.3V
230V
VU 39
ANODE VOLTS
ANODE SUPPLY
V
0-300
40μF
8μF
B. SCREEN SUPPLY
6X5G
SCREEN VOLTS
SCREEN SUPPLY
12 × 1kΩ
8μF
8μF
0-300
C. BIAS SUPPLY
BIAS SUPPLY
50μF
0-30
20kΩ
6μF
6μF
GRID BIAS
2V
4V
50V
0
50V
VU39
230V

Circuit Diagrams.

2. Ia/Vg CURVES.




A sinusoidal time base for the X plates is provided by the voltage across R1. A voltage varying at the same frequency is applied from R2 to the grid of the valve under "test", alternately opposing and assisting the standing G.B. The position of the spot along the X axis will therefore correspond to the voltage applied to the grid of the valve.

The voltage across the anode load will correspond to the anode current, which, in turn, will correspond to the grid voltage. If this voltage is applied to the Y plates the spot will trace a distance in the vertical direction corresponding to the anode current. As the two movements of the spot are combined it will trace out the Ia/Vg Curve.

The anode load is comparatively small so that the characteristics obtained will be nearly the "static" curves. The output is therefore small and the use of the Y1 amplifier is necessitated.

Making the load too small would cause the anode circuit to be mainly capacitive, thereby causing a phase shift in the anode voltage, so that it would not correspond directly to the grid voltage. The forward and return traces would then be badly out of alignment and a large loop would result.

To overcome this tendency the smoothing condenser is made large and a special circuit incorporated in the C.R.O. to "black-out" the return trace if necessary.

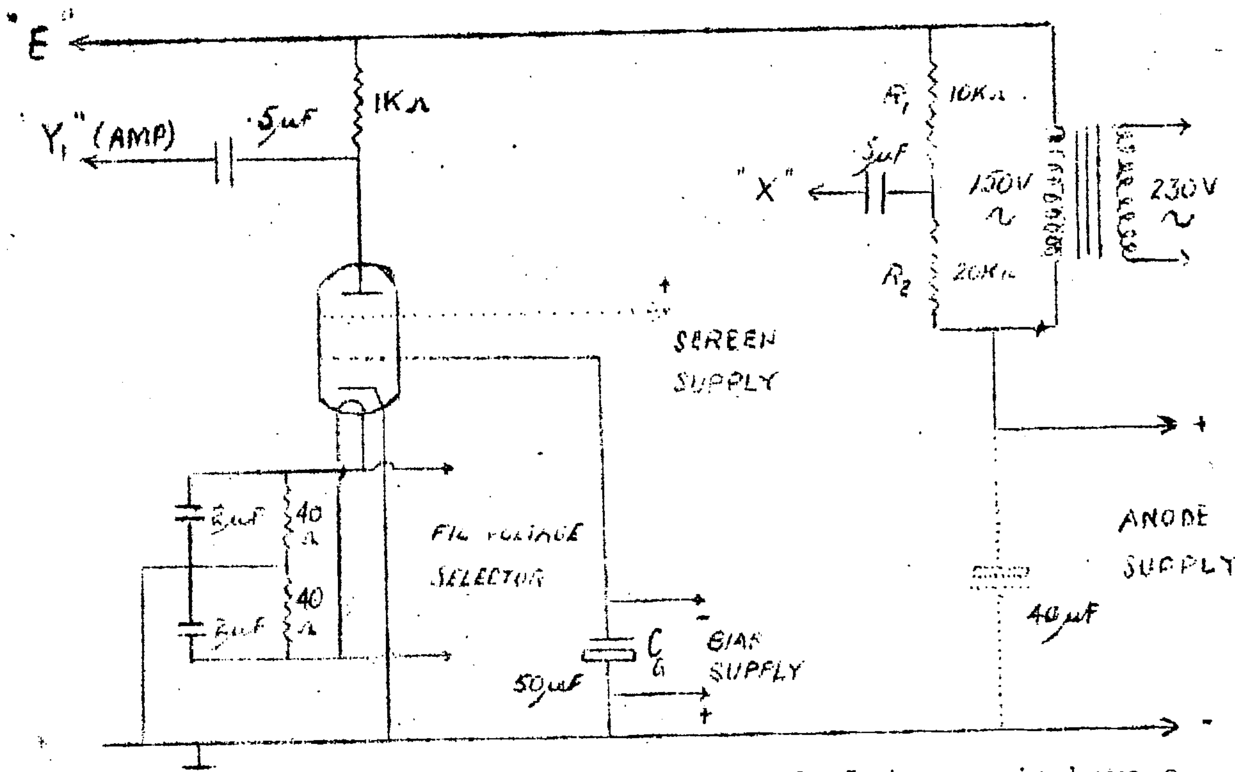
Although the resistance in the grid circuit has been made as small as possible, grid current due to positive grid drive still damps the "drive" circuit, reducing the drive and "flattening" the top of the grid characteristic. The peak grid drive should therefore be adjusted so that grid current does not flow.

The filament humdinger is to effectively centralise battery filaments to earth.

By varying the anode and screen voltages "families" of Ia/Vg Curves can be obtained.

Circuit Diagrams.

## 3. Ia/Va Curves.




To produce an Ia/Va characteristic the X plates again have a sinusoidal time base applied, this being obtained from the voltage across R1. The anode voltage also varies sinusoidally from just below zero, when the voltage across R1 and R2 opposes the anode supply, to about 350V when this voltage assists the anode supply. Distances moved by the spot in the X direction therefore represent the anode voltages.

The corresponding variations of anode current develop a voltage across the anode load, which is applied to the Y plates (via amplifier). Distances moved by the spot in a vertical direction therefore correspond to the anode current.

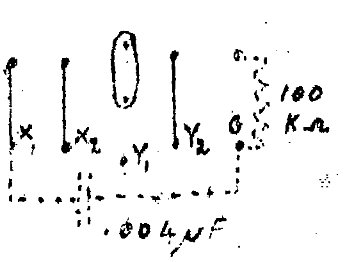
Combination of the two movements produces the required Ia/Va Curve.

The return trace may be "blacked-out" if necessary.

"Families" of Ia/Va Curves can be obtained by varying the grid and screen potentials.

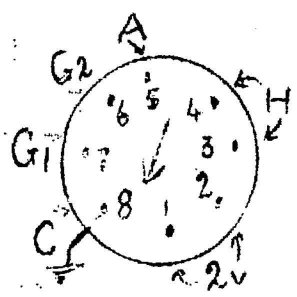
---

A. MODIFICATION FOR C:R:O. FLYBACK SUPPRESSION:

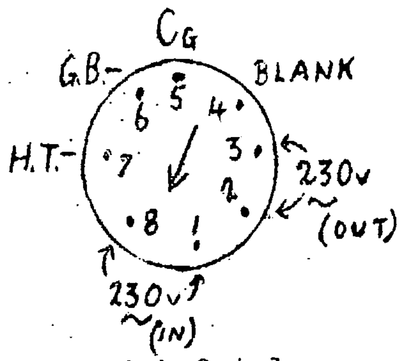



Rear Panel,
Cossor C.R.O. Type 10

B. INTERCONNECTION: UPPER AND LOWER PANELS



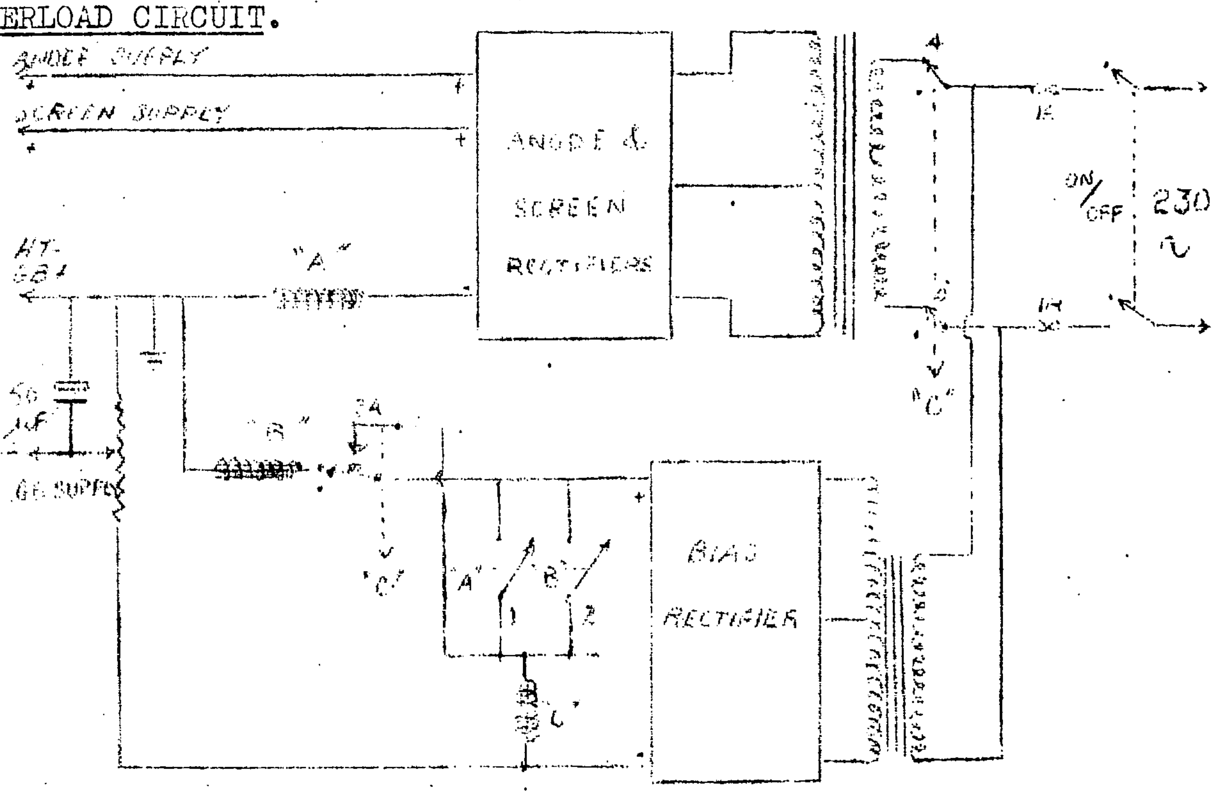

International Octal Plug




British Octal Plug

Circuit Diagrams.

4. OVERLOAD CIRCUIT.




An overload on the H.T. circuit will cause relay "A" to become energised, and an overload on the bias circuit will cause relay "B" to become energised. Similarly an overload involving both circuits will cause both relays "A" & "B" to become energised. The energising of either "A" or "B" relay will close either contacts 1 or 2 respectively. Either of these will complete the "C" relay circuit and thereby close contacts 3a, 3b, 4 and 5.

Contact 3b will open the bias circuit, isolating any overload in that circuit, and 3a will act as a "holding" contact for "C" relay. Contacts 4 and 5 will open the input circuit of the H.T. Rectifiers, isolating any overload in the H.T. section.

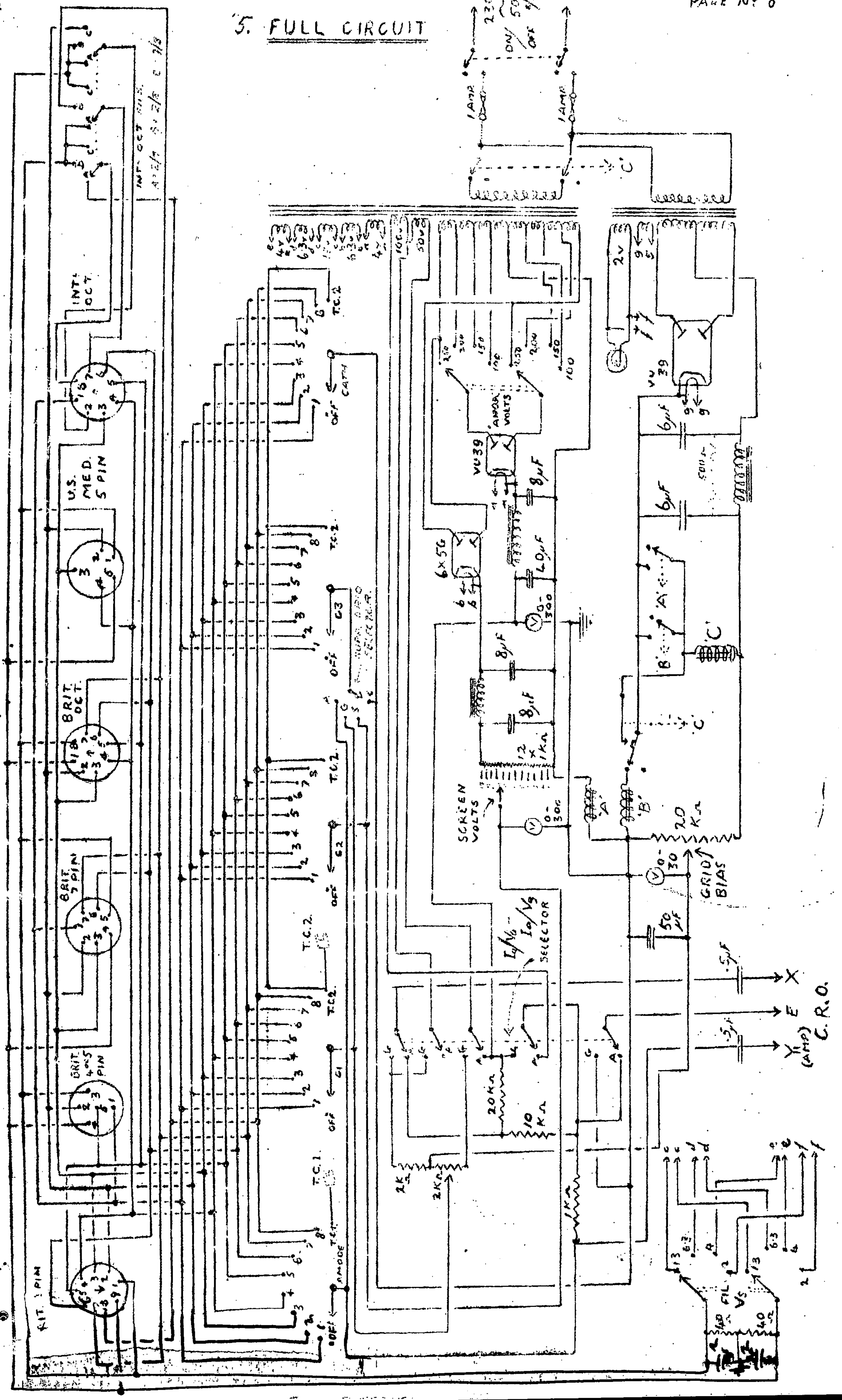
When the overload is isolated "A" & "B" relays will be de-energised, and contacts 1 and 2 will open. The "C" relay contacts (3a and 3b) are such that the "C" relay is energised before this occurs.

The overload having been removed, in order to de-energise "C" relay the On/Off switch must be opened.

Two 1 Amp fuses in the mains input leads provide additional protection.

The "chattering" of either "A" or "B" relay indicates that the load on one of the two circuits is becoming excessive.

## 5. FULL CIRCUIT



# INSTRUCTIONAL OPERATION.

The object of these demonstrations is not to replace their work on the valve boards, but merely to show the pupils very easily and quickly several interesting facts which they would not normally discover themselves. Whilst the plotting of characteristics on graph paper helps the pupils to remember the salient differences between, say, a triode and a pentode, the advantage of an oscilloscope is that every member of the class is seeing the same thing; whereas on individual experimental boards, a slow pupil may never finish all the experiments, or a stupid one complete one incorrectly. The oscilloscope, in the hands of a competent operator, can produce correct curves in a short space of time, and assist an instructor in putting over the "gen".

Another important point is that an oscilloscope will show the class what happens as the valve warms up. This may not seem of great importance, but the controlling effect of the electrodes varies with electron densities, and a wealth of information is included in this brief period, which can be shown on the screen.

Precautions. First, read General and Setting-up Instructions carefully.

RULE: IF IN DOUBT SWITCH OFF.

When comparing valves it is easy to forget to alter the electrode switches and filament voltage settings, especially the latter. Due care in these matters, apart from the consideration of equipment being damaged, will prevent the demonstration being spoilt by unnecessary interruptions, due to burnt out valves, etc..

N.B. Top cap connections and metallising may be at a high potential with respect to chassis; therefore be careful when handling them, and also, do not let them "short" to the case.

---

When comparing valves do not alter the Y1 Amplifier setting.

---

Ia/Vg.

The possible variations of Ia/Vg characteristics between various types of valves is limited, but it is instructive to illustrate the difference between a straight and variable-mu valve.

As it is difficult to get the Ia/Vg curve of a valve accurately at the first setting of the controls, in order not to confuse the trainees unnecessarily the instructor should make himself thoroughly conversant with the controls before attempting to give a demonstration.

Suggestions. (See the appropriate section for Control Settings and optimum voltages).

Triodes.

Compare the slopes of a VR21 (low), VR40 or VT 105 (medium), and VR 505 (high).

Show the effect of varying the anode voltage in all cases, slight variation in slope in each case, and shortening of "grid base" as Va is decreased.

Note large differences in case of Vr 40, indicating low Ra. This can be confirmed by comparison of its Ia/Va slope with that of the other valves.

Instructional Operation.

Ia/Vg (continued).

Tetrodes.

Compare VR 18 and VR 28 slopes.

These show very clearly the difference between straight and vari-mu valves.

In each the effect of varying screen and anode volts can be shown. The anode voltage will have little effect, indicating a high Ra (can be shown on the Ia/Va Curve), while it is clearly shown that the screen voltage has a far greater control over the valve.

The change of slope, etc., for differing screen voltages should be noted.

Pentodes and Beam Tetrodes.

These are very similar and any valves may be chosen.

Again, slope variation and the far greater control shown by the screen voltage than the anode voltage can be demonstrated.

It is instructive to compare the steep slope, short grid base, Vr 91 with the vari-mu VR 53.

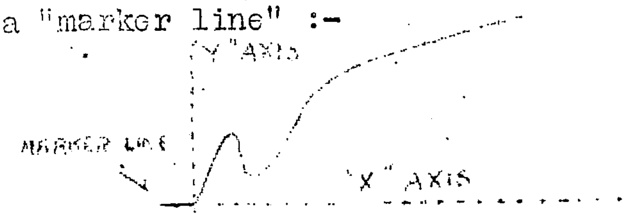
In the case of some VR 91.s connecting the suppressor grid to the grid will change the curve from the "straight" to the vari-mu type.

N.B. Some steep slope valves (VR 505 and VR 91) show a tendency to oscillate on the Ia/Vg setting of the Selector Switch.

---

Ia/Va.

In the case of the Ia/Va characteristics the two axis are indicated by a "marker line" :-




This is obtained by using the min. anode volts position. The peak A.C. swing is then higher than the anode D.C. potential and on the negative half-cycle the anode will go negative, producing the "marker line" as shown.

In order to shorten the "marker line" and thereby show more of the curve, Anode Volts setting No.2 may be used with some valves; but care must be taken not to eliminate the marker line entirely.

Suggestions. (See the appropriate section for Control Settings and Optimum Voltages).

Triodes.

Compare the slopes of a VR 21 (high Ra), Vr 40 or VT 105 (low Ra), and Vr 38 or VR 505 (medium Ra).

The effect of varying the G.B. can be shown in all cases - "movement" of slope to right indicating reduction of all anode currents as G.B. increases.

Variation of slope (Ra).

Tetrodes.

These are the most interesting of all the curves.

The "kink" should be clearly shown, and its relation to the "marker line"; especially where it goes below the latter, indicating "reverse current".

The effect of varying screen potentials on the "depth" of the "kink" is particularly instructive.

Suitable Valves. VR 18 or VR 28, and VR 107 (with osc. grid and anode not used).

Variation of bias has little effect on the shape of the curve, serving mainly to alter its amplitude. The slope of the "working" part of the curve shows slight differences for different bias values.

Instructional Operation.

Ia/Va (Continued).

Beam Tetrodes. VR 100, VR 118, VT 60 or VT 75A.

These curves should be very similar to those obtained by pentodes, with the exception of a sharper "knee" where the curve bends over. Attention should be drawn to these facts.

The above only hold true if the current bias is applied, so care should be taken in this direction.

The electron density between screen and anode is a controlling factor in beam tetrodes, as it helps to repel secondary emitted electrons from the screen. Too low an electron density will therefore allow secondary electrons to reach the screen and produce traces of a "kink". Increasing the bias negatively beyond the optimum working point will produce this kink, and this tendency of beam tetrodes should be demonstrated.

As the VR 118, VT 60A and VT 75A are output valves the slope of the working part of their curves will be fairly steep, indicating a moderately low Ra. This slope, and also the amplitude of the curve can be varied by altering the screen potential.

Pentodes.

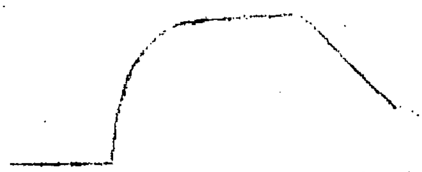
Compare R.F. pentodes (high Ra), e.g. VR 91, VR 53, VR 106, with output pentodes (moderate Ra), e.g. VT 51, VT 52, and show the effect of varying bias and screen potentials.

The bias voltage is very critical in the case of the VR 91.

The vari-mu valves (e.g. VR 53) show the changing degree of control exercised by the G.B. as it is increased.

VT 52. As this valve has a max: anode dissipation of 5.7 the bias must not be decreased below -7.5V or this figure is likely to be exceeded. At high bias values, as the suppressor grid pitch is wide in an output pentode, the reduction of electron density will produce a small kink, which can be shown.

A soft valve will give a curve as shown:-



This distortion can be eliminated by increasing the bias above -7.5V, thereby increasing the anode voltage necessary to produce ionisation.

---

Suppressor Grid Switch.

For pentodes in which the suppressor grid is brought out to its own pin (e.g. VR53, VR 91, VR 106) an interesting and edifying demonstration can be given by first connecting the suppressor grid to the screen grid (G2), thereby effectively making the valve into a tetrode.

The Ia/Va curves relating to a tetrode can then be shown first, proceeding as for a normal tetrode demonstration. Then the effect of the "inclusion" of the suppressor grid can be clearly and decisively shown by connecting it to the cathode.

---

Warming Up.

To show the effect of the warming up period for either Ia/Vg or Ia/Va curves, the U.V.C.D. should first be set up to give the required final characteristic of the valve in use. The valve should then be removed and allowed to cool. On plugging in again the required effects will be shown. (e.g. alteration of slope and early saturation).

---

The foregoing is by no means the limit of the scope of the

Instructional Operation (Continued).

U.V.C.D., but a selection of its most useful applications for training demonstrations.

The competent instructor should be able to work out a satisfactory programme of his own, if necessary, to suit the standard of his particular class.

| Valve Type No. | Base (See below) | ELECTRODE SWITCH POSITIONS Anode | Grid (G1) | Screen (G2) | Suppr (G3) | Cathode | Fil Vol | SCREEN Opt | Max | Ia/Vg G.B. Appro | Ia/Va MIN G.B. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VR18 | B4 | T C 1 | 2 | 1 | OFF | OFF | 2.0 | 120 | 120 | -12 | 0 |
| VT20 | B4 | 1 | 2 | OFF | OFF | OFF | 2.0 | - | - | -14 | 0 |
| VR21 | B4 | 1 | 2 | OFF | OFF | OFF | 2.0 | - | - | -10 | 0 |
| VR22 | B4 | 1 | 2 | OFF | OFF | OFF | 2.0 | - | - | -12 | 0 |
| VR27 | B4 | 1 | 2 | OFF | OFF | OFF | 2.0 | - | - | -10 | 0 |
| VR28 | B4 | T C 1 | 2 | 1 | OFF | OFF | 2.0 | 120 | 120 | -12 | 0 |
| VR38 | B5 | 1 | 2 | OFF | OFF | 5 | 4.0 | - | - | - 7 | 0 |
| VR40 | B4 | 1 | 2 | OFF | OFF | OFF | 4.0 | - | - | -14 | -4 |
| VT51 | B5 | 1 | 2 | 5 | OFF | OFF | 2.0 | 120 | 120 | -12 | 0 |
| VT52 | 1.O. | 3 | T.C.2 | 4 | OFF | 8 | 6.3 | 150 | 200 | -20 | -7.5 |
| VR53 | 1.O. | 3 | T.C.2 | 4 | 5 | 8 | 6.3 | 200 | 200 | -15 | 0 |
| VR57 | 1.O. | 3 | T.C.2 | 4 | OFF | 8 | 6.3 | 150 | 150 | -10 | 0 |
| VT60A | USM5 | T.C.1 | 3 | 2 | OFF | 4 | 6.3 | 120 | 200 | -12 | -3 |
| VT75A | B7 | T.C.1 | 2 | 7 | 3 | 6 | 4.0 | 100 | 100 | -10 | -4 |
| VR91 | B9G | 3 | 7 | 2 | 4 | 6 | 6.3 | 200 | 200 | - 2 | 0 |
| VR99 | 1.O. | 3 | T.C.2 | 4 | OFF | 8 | 6.3 | 200 | 200 | -12 | 0 |
| VR100 | 1.O | 3 | T.C.2 | 4 | OFF | 8 | 6.3 | 200 | 200 | -25 | 0 |
| VR101 | 1.O | 3 | T.C.2 | OFF | OFF | 8 | 6.3 | - | - | -10 | 0 |
| VR102 | 1.O | 6 | 5 | OFF | OFF | 8 | 6.3 | - | - | -15 | 0 |
| | | 3 | T.C.2 | OFF | OFF | 4 | | | | | |
| VT105 | B5 | 1 | 2 | OFF | OFF | 5 | 6.3 | - | - | -15 | -3 |
| VR106 | B7 | 2 | T.C.2 | 7 | 3 | 6 | 13.0 | 150 | 200 | -12 | 0 |
| VR107 | B7 | 7 | T.C.2 | 3 | OFF | 6 | 13.0 | 120 | 200 | - 8 | 0 |
| VR109 | B7 | 7 | T.C.2 | OFF | OFF | 6 | 13.0 | - | - | - 3.5 | 0 |
| VR118 | B5 | 1 | 2 | 5 | OFF | OFF | 2.0 | 200 | 200 | -10 | 0 |
| VR505 | B5 | 1 | 2 | OFF | OFF | 5 | 4.0 | - | - | - 2 | 0 |

(The filament pin selector switch position for all the above valves is 2/7. For valves not listed above check fil: pins).

VALVE BASE ABBREVIATIONS.

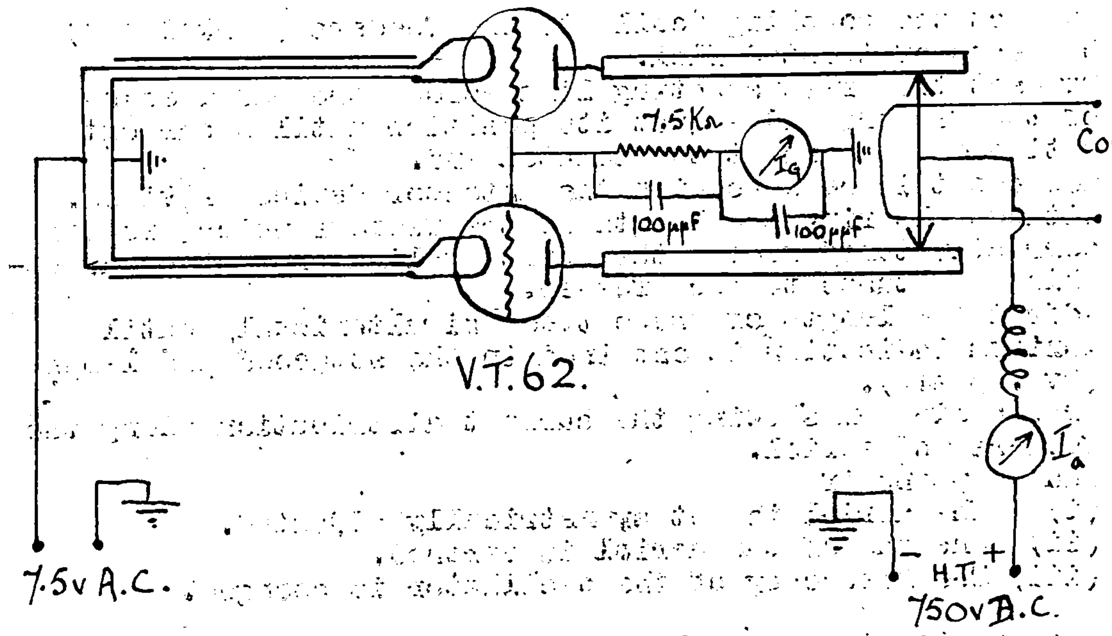
B4 British Standard 4-pin
B5 British Standard 5-pin
B7 British Standard 7-pin
1.O. International Octal
B9G British 9-pin Glass
USM5 American Medium 5-pin

N.B. For Electrode Switch settings and fil: volts of valves other than those listed above see VALVE TESTER, TYPE 4A, HANDBOOK, (A.P.2537B, Vol:1, FIRST EDITION).

# AERIAL INSTRUCTION.

**Experiment 1.**

Frequency Measurement - Use of tuned feeders.




The above oscillator is used for this experiment.
It must always be remembered that the H.T. supply is 750 volts and under no consideration should the anode lines be touched or any adjustment made without first switching off the H.T. supply.

Connect the coupling link via twisted flex to one end of a lecher bridge. Switch on the L.T. supply then the H.T. supply.

(a) Starting from the feed end of the lecher ~~curves~~ lines adjust the position of the shunting bridge until standing waves appear on the lecher lines.
This position can best be found by holding a pea lamp attached to a loop wire so that, the loop is loosely coupled to the anode circuit of the oscillator; when standing waves are developed on the lines, the brilliance of the pea lamp coupled to the anode circuit will fall off sharply. Why does this occur?
Take the reading of the position of the shunting bar on the bridge.

(b) Move the shunting bar farther from the fed end of the lecher lines until a second position is obtained when standing waves are developed.
Note the position of the shunting bar.

(c) Determine a third position of the shunting bar in which standing waves are developed on the lecher wires.
With the aid of the detector device provided determine the position of current and voltage nodes and antinodes on the lecher system.
Draw a diagram to illustrate the standing current and voltage waves on the lecher system.
Indicate points of maximum and minimum impedance.
Change the frequency of the oscillator slightly do standing waves still appear on the lecher lines.
Why is this?
Compare the differences between readings (b) & (a) and (c) & (b) obtained above.
Calculate the frequency of the oscillator output.
Why is it not good practice merely to take the first reading (a) when carrying out frequency measurements.

/2.

2. Adjust the position of the shunting bar in the oscillator anode first for highest and then for lowest frequency output.
Using the lecher system determine the frequency range of the oscillator.

3. Adjust the oscillator for operation at 200 Mc/s.

(a) Method of using tuned feeders to centre feed a half wave aerial.
Connect the coupling "coil" to the feeders (marked "A") by means of twisted flex.
Connect the brass shunting link across the unfed ends of the feeders and adjust its position until a current antinodes appears at the shunted end.
How can this be done with the detector device provided.
Without altering the length of the feeders which are now correctly tuned remove the shunting link and attach adjustable tubes to each feeder.
Adjust the length of these tubes simultaniously until maximum indication is obtained in the attached pea lamps (2v . 3 amp).
Draw a diagram showing the current distribution along the feeders and aerial.
What happens if
(i) The aerial is not symmetrically adjusted.
(ii) One end of the aerial is earthed.
(iii) The frequency of the oscillator is changed.

Account for these results.
Why have the above two steps been effected in order to feed the dipole?
Measure the lengths of feeders and dipole.
Do your measurements agree with theoretical considerations.
If not, how can you suggest any possible explanation for these discrepancies.

4.(a) Method of using tuned feeders to end feed a half wave aerial.

With the transmitter adjusted for operation at 200 Mc/s.
Connect the coupling coil to the feeders (marked B) by means of the twisted-flex lead.
Adjust the open ends of the feeders until standing waves appear on the feeders.
What is the best method of checking this with the detector device provided?
Connect the adjustable aerial to one feeder and vary its length for maximum indication of aerial current.
Outline the current and voltage distribution on both feeders and aerial.
What happens if the frequency of the oscillator output is varied. Why should this occur?

This voltage fed dipole ~~with~~ has tuned feeders which owing to heavy standing waves and unbalanced load on them always radiate to some extent. The feeders should therefore be kept as short as possible and are usually made an odd number of quarter wavelengths long.
Why should this be?
For low power amateur transmitter work this system is very popular.
Give sketches to explain this statement.

REF. A.R.R.L HANDBOOK.
ANTENNA HANDBOOK.
R.S.G.B. HANDBOOK.
A.P. 2514.

EXPERIMENT NO.2.

"Y" or Delta Matched Dipole.

The transmitter provided consists of an M.O. Stage and a push pull P.A. stage link coupled to a tuned aerial circuit.
600 ohm feeders are provided and an aerial cut to length for 20 Mc/s operation.

$$l = \frac{468}{20} \text{ feet.}$$

How is this expression derived?

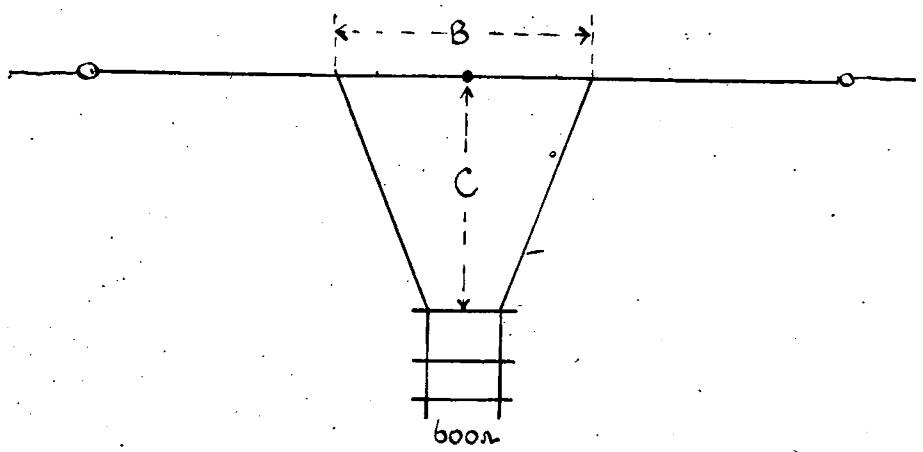
The following adjustments are to be made:-

1. With the aid of the modified W.1117 operated from the A.C. mains adjust the M.O. stage to oscillate at 20 Mc/s using the calibration chart and correction scale provided.

2. Tune the P.A. stage to the M.O. with feeder lines disconnected. Check that transmitter is still on frequency.

3. Tune the aerial circuit for maximum transfer via the link coupling.
What indication can be used for this adjustment?
If two 600 ohm feeders are connected about .06 wavelength on either side of the centre of a dipole, then if the input to the feeders is balanced to earth the feeders will carry equal antiphase currents as they are correctly terminated in a balanced load.

4. Connect the feeders to the dipole as indicated in Sketch below.




For 600 ohm lines.

B = .12 wavelength or $\frac{123}{F}$ feet F in megacycles.

C = .15 wavelength or $\frac{148}{F}$ feet F in megacycles.

The centre of dipole is indicated by a solder spot.

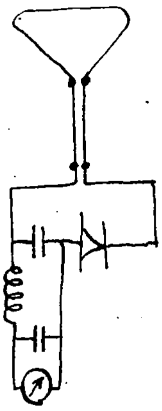
Attach the other ends of the feeders via the feed meters to the aerial circuit. Adjust the positions of attachment to the aerial circuit until the indications of the feeder meters are equal and have maximum value.

( It is necessary to tune both aerial and P.A. circuits when the feeder taps are changed. - Why should this be so? )

Under what conditions will the feeder currents be equal and have maximum value?

5. Measure the standing waves on each feeder with the indicator provided, and if the feeder currents are unbalanced move the "Y" as a whole along the dipole to the right or left until the currents are balanced.

## STANDING WAVE DETECTOR.



How does this detector operate?
What other type of instrument could have been used.
Why is the former superior?

6. To reduce standing waves alter the distance B. slightly not more than a few inches will be necessary at 20 Mc/s.

If the aerial is unsymmetrically disposed with regard to neighbouring buildings, hangars or metal structures (as in laboratory) it may be found that the points of attachment of feeders giving minimum standing wave ratio are such that the feeders are not symmetrically attached to the aerial.
The feeder currents should not vary by more than 5% ~~link~~. 10% is ~~best~~ as good a figure as can be obtained in the laboratory.

7. At frequencies in the neighbourhood of 20 Mc/s slight adjustment, usually decrease of the order of a few inches, in C, may assist final reduction of standing wave ratio.

It must be understood that the lengths B & C are critical to an inch and every endeavour is to be made to obtain minimum standing wave ratio but the process is slow and laborious.

Record your final measurements for the distances B & C.

Describe briefly the mode of operation of a delta match.

----------oOo----------

## EXPERIMENT NO. 3.

Detection of standing waves on transmission lines.

The transmission lines are connected to a variable frequency V.H.F. oscillator whose output is in the neighbourhood of 200 Mc/s.

( It must be remembered that voltage in )
( the anode line is 750 v. D.C. )

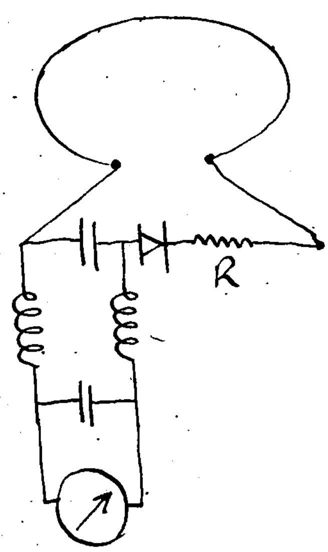
Set the oscillator to its middle frequency output by adjusting the position of the moveable anode shunting bars to middle position.

### Current Distribution.

1. (a) Place the sliding current detector labelled C on the bridge and adjust its position for maximum indication near the centre of the bridge. Vary the place of the indicator coupling loop relative to indicator box until a reading of about 400 is obtained.

   (b) Starting at the beginning of the bridge scale take a reading of the meter deflection. Move the meter 5 cm. at a time and take corresponding readings of meter deflections.
   Note it is probably best to read the position of the front edge of the indicator over the meter scale.
   It will be noticed that proximity changes the readings appreciably: hence always take readings when in the same relative position to the lines.

   The meter indicates current distribution.
   The circuit is given below.




R current limiting resistance to safeguard crystal.

2. Tabulate all readings as below.

| Position of meter cms. | Current Indication. | Voltage Indication. |
|---|---|---|

3. Voltage Distribution.

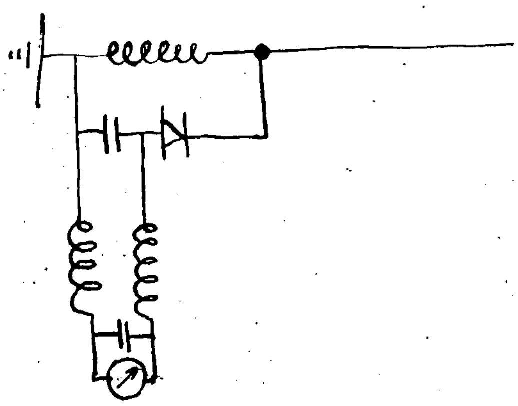
Place the voltage indicator labelled V on the bridge and slide it along until it indicates a maximum near the centre of the bridge.
Adjust the length of the pick-up aerial until a meter reading of approximately 400 is obtained.

Replace the CURRENT indicator on the bridge in the position where the first current reading was taken. - Note the position of the centre of the pick-up loop.

Remove the current indicator and place the VOLTAGE indicator in such a position that the PICK UP AERIAL OCCUPIES THE SAME POSITION AS THE CENTRE OF CURRENT LOOP OCCUPIED.

Take the reading of the voltage indicator.
Move the indicator forward by 5 cm. steps taking corresponding meter readings. Hence comple the table shown above.

The meter indicates voltage distribution.
The circuit is given below.



4. Plot these readings of current and voltage distribution - is there any apparent relationship?

5. Short the remote ends of the feeders and repeat the experiment.

6. Place the two indicators at voltage and current antinodes respectively and change the frequency of the oscillator.

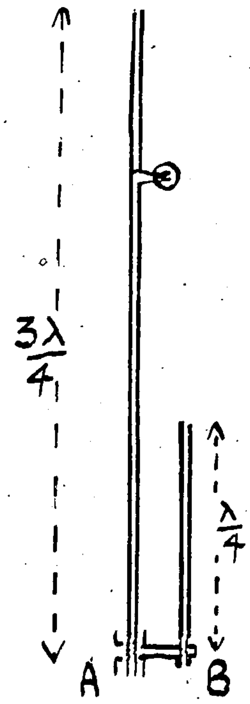
Are the meters still at antinodes.
Account for this variation.

-----------oOo-----------

# AERIAL INSTRUCTION.

## EXPERIMENT IV.
The Type J Aerial.

A. This aerial, which is employed in the Service for V.H.F. work is a combination of an end fed half wave aerial with a quarter wave matching section.




The aerial in the laboratory has been assembled for 200 Mc/s operation.

(i) Attach the coaxial socket carrying a brass spacing bar as shown at A, by screwing the projecting end into the bottom of the longer aerial member. Connect the spacing bar to the shunter member of the aerial by means of a 4 B.A. bolt at B. It may be necessary to raise or lower the shunter member of the aerial system, by slackening the two holding bolt located in the insulating supports.

(ii) Connect at A one plug of the coaxial feeder labelled X. ($Z_o$ = 50 ohms).

(iii) Connect the socket on the chassis to the output coupling coil of the oscillator by means of the twisted flex leads provided.

(iv) Connect the other end of the coaxial feeder to the socket on the oscillator chassis.

(v) Switch on the oscillator and adjust the output frequency for maximum indication in the longer member of the aerial.
Why should there be one particular frequency at which this condition is satisfied.
Draw a diagram to illustrate current and voltage distribution on both members of the aerial.
In this case since the oscillator output power is small useful information may be ontained by touching the aerial at certain points.

The quarter wavelength section of the J aerial is incorporated to match the coaxial feeder to the open end of the half wavelength aerial.
Hence if $Z_f$ $Z_a$ $Z_o$ are the impedances of the feeder, the aerial at a voltage antinode and the quarter wavelength section.
For optimum match.

$$Z_o = Z_f \; Z_a$$

Using a 50 ohm coaxial cable ($Z_f$ = 50) and assuming the impedance at a voltage antinode to be 2500 ohms.

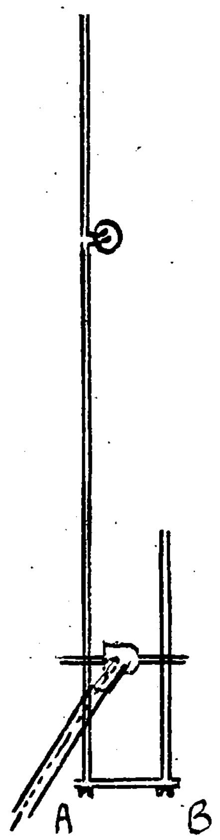
$$Z_o = 50 \times 2500 \text{ ohms.}$$

In order that the impedance matching section shall have the correct impedance the spacing D between its members will depend on their diameter d.

$$Z_0 = 276 \log \frac{2D}{d}$$

Measure the diameter of the aerial tubes and calculate D.
Compare the calculated result with the actual spacing.

B. The above type J aerial can be modified for use with feeders of different impedance from that used above. In this case the two members of the aerial are shunted at the bottom and the device then becomes an end fed half wavelength aerial with a quarter wavelength transformer.




(i) Remove the coaxial and the socket with spacing bar by unscrewigg the 4 B.A. bolt at B.

Fig. 1. and the socket at A.

(ii) Connect the bottom ends of the aerial members by means of the brass connecting strip provided attaching it at A and B by means of 4 B.A. bolts.

(iii) Connect coaxial feeder labelled Y ($Z_0$ = 100 ohms) to the socket in the oscillator chassis.

(iv) Switch on the oscillator and adjust the point of attachment of the coaxial to the quarter wave transformer until maximum brilliance is obtained in the aerial indicator bulb.

(v) Account for the position of attachment of the feeder.

(vI) Repeat the above experiment using the twisted flex feeder labelled F. This is best connected directly to the coupling coil at the oscillator end.

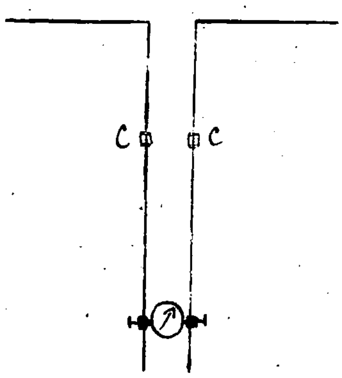
How does the impedance of this feeder compare with that marked Y; qualify your observation.

# AERIAL INSTRUCTION.

**Experiment V.** - Half Wave Transformer.

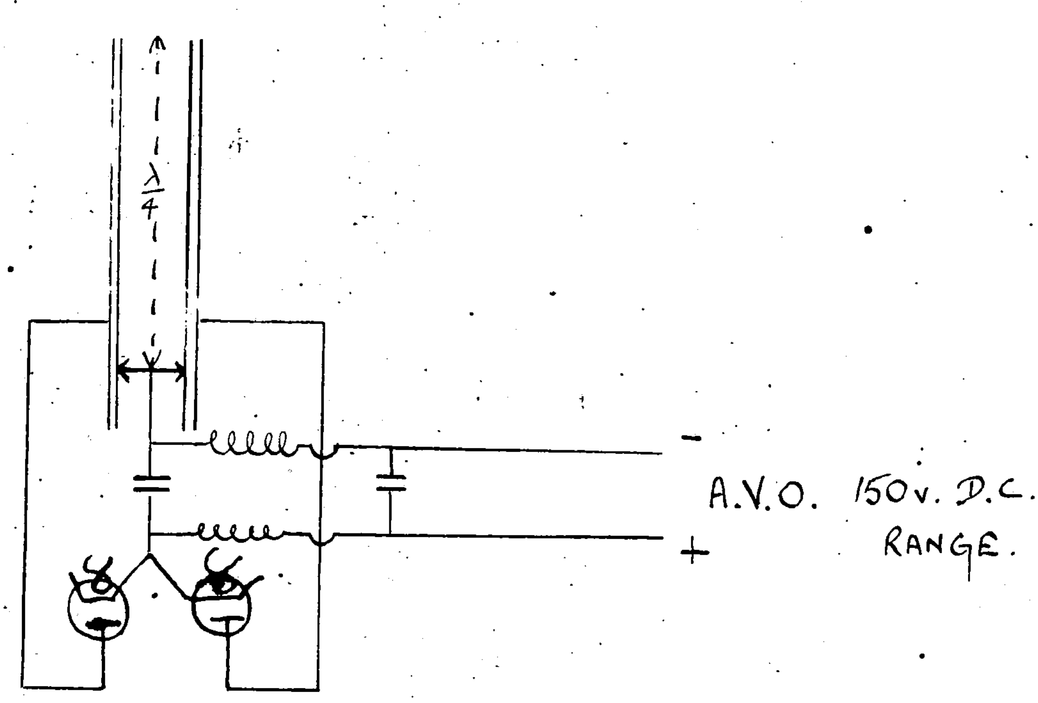
**A.** With the aid of a lecher bridge adjust the frequency of the oscillator for 200 Mc/s operation. Connect the coupling coil of the oscillator to the 600 ohm lines provided. To the other end of the lines attach the auxiliary dipole by means of the twisted flex lead. Support the auxiliary dipole in the socket at the ends of the 600 ohm lines.

The aerial provided is cut for 200 Mc/s operation attached to the dipole as shown in figure are two rods more than half a wavelength long.




At the bottom of the rods are two adjustable lugs designed to carry a meter which will short the matching rods.
Attach a 0 - 120 thermal milliammeter to the lugs on the matching rods.
Switch on the oscillator and adjust the position of the meter for maximum current.

Draw a sketch illustrating the distribution of current and voltage on the shunted rods and attached dipole.
Switch off the oscillator, remove the 0-120 thermal milliammeter and replace it with a 0-2.5 thermal ammeter.
Remove the auxiliary aerial.
Raise the adjustable connectors on the matching rods, to the highest possible position and clamp them on the same horizontal level. Attach these connectors to the ends of the 600 ohms lines by means of tuned wire. So not allow these lines to be slack.
Switch on the oscillator and measure the standing wave ratio by means of the detector described below. (Note the diode heating circuit is to be connected to one of the 6.3v A.C. sockets).



8

How does this detector operate?
Why should the detector tubes be adjusted to quarter wavelength?

Lower the position of the connectors by centimetre steps until minimum standing wave ration is obtained. This should be of the order of 2 to 1 ratio.

Final reduction of standing wave ratio is obtained by lowering or raising the meter at the bottom of the matching transformer.
The standing wave ratio should thus be reduced to at least 1.2 to 1.

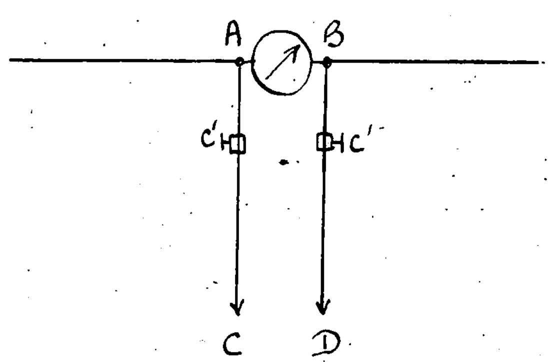
Describe briefly how the impedance match has been secured.

B. Quarter Wave matching Transformer.

Set the oscillator provided to operate at a frequency of 200 Mc/s.
Connect the output coupling coil of the oscillator to the 600 ohms lines provided. Attach to the other end of the 600 ohm lines an auxiliary dipole by means of the twisted flex pair.

Insert the dipole in socket near the end of the 600 ohm lines.

A second dipole cut for 200 Mc/s operation is provided. This dipole has attached at its centre two adjustable rods A.C. and B.C. By slacking the 2. B.A. nuts at A and B, insert a ) 0-500 thermal milliameter as shown in sketch.




Switch on the oscillator and adjust the lengths of A.C. and B.D. by equal increments until the meter current is a maxinum.
When will this occur? Draw the current and voltage distribution in this condition.
Switch off the oscillator and remove the meter between A and B.
Remove the auxiliary dipole.

Raise the connectors (on A.C. and B.D. to their highest position. Attach leads to the connectors and join their other ends to the 600 ohm lines. Ascertain that these leads are tight. Switch on the oscillator and measure the standing wave ratio on the 600 ohm lines, with the diode detector.

Lower the connectors by centimetre steps, shortening the leads to prevent any sogging, until minimum standing wave ratio is obtained

Final reduction of standing wave ratio may be secured by increasing or decreasing the length of A.C. and B.D. very slightly.

Describe briefly how the impedance match has been secured.

# AERIAL INSTRUCTION.

Experiment VI - Field of Dipole Aerial, Use of reflectors for transmission and reception.

The transmitter provided is a push pull tuned line oscillator operating at 300 Mc/s. The associated power supplies which are mains operated supply power for the blower motor the valve anodes being air cooled, the filaments of the valves and H.T. The switching is interconnected so that the blower must first be switched on before the valve filaments, and the filaments before the H.T.

NOTE:- The filaments are Tungsten and therefore they must attain their working temperature before the H.T. is switched on, otherwise the life of the valves will be seriously reduced. Therefore switch on the blower and the filaments but wait at least thirty seconds before switching on the H.T.

The output from the transmitter is taken via a twisted flex lead to the centre of a dipole located on a measuring bench.

(i) Observation of dipole field.

Locate energised aerial at the centre of measuring bench.

Place the receiving aerial with a 2.5 volt bulb at its centre on the bench in such a position that the bulb lights fairly brightly (usually above 50 cm from the energised aerial).
Holding the receiving aerial horizontally and parallel to the radiating element rotate the aerial in a vertical place at a constant distance from the transmitting aerial.
What do you observe?
Locate the receiving aerial in its original position and move it in a direction parallel to the energised aerial.
What do you observe?

Observe the "end-on" pick-up by holding the receiving aerial in the same plane as the energised aerial but in an end - on position.

(ii) Plane of Polarisation.

Locate the receiving aerial in its original position. Rotate it in the horizontal and vertical planes by lifting in slightly above the measuring bridge.
What do you observe? Account for this.

(iii) Operation of Reflectors.

A. For transmitting aerial.
With the energised aerial at the centre of the bridge, place a receiving dipole in such a position that the indicator just lights.
Place at the other end of the bench a continuous dipole (i.e. without lamp).
Advance this dipole towards the energised aerial noting the positions at which the receiving aerial is:-

(1) Most energised.
(2) Least energised.

Compare the distances of the reflector with wavelength (f = 300 Mc/s) and account for your results.

B. For receiving Aerial.

Locate the energised aerial at the 50 cm mark and the receiving aerial at 130 cm mark. Adjust the position of a transmitting reflector for maximum signal in the receiver aerial.
Locate another continuous dipole on the bench behind the receiving aerial.
Adjust the position of this dipole for maximum signals in the receiver aerial.

How therefore could you improve the signal strength of a distant transmission.

Repeat the above two experiments using reflecting elements of lengths

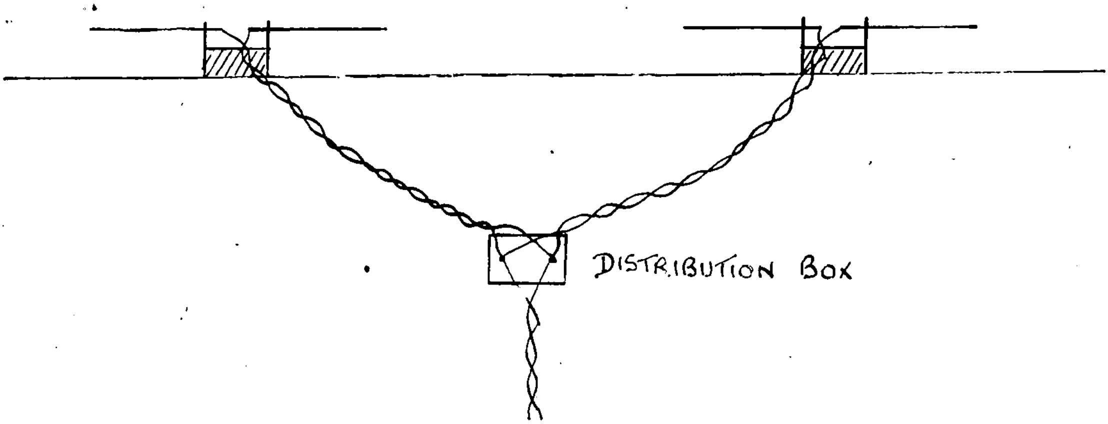
Why should differing results be obtained?

(iv) Broadside Radiation.

Locate the energised aerial at the 50 cm mark and the receiving dipole at 150 cms mark on the bench. Hold a reflector parallel with the energised aerial and immediately about it. Gradually raise the reflector in a vertical place observing the indication in the receiver aerial. Compare the height of the reflector above the energised aerial with the wavelength of the radiated signal when maximum signal is obtained in the receiver aerial.
Repeat the above using the reflector above the receiving aerial.

V Effect of inphase and out of phase feeding aerials.

Assemble two dipole aerials on the measuring bench as indicated below. Note two specially mounted aerials are provided such that they can be moved along the bench with their axes parallel to the length of the bench.




(a) Connect the twisted feeder from the transmitter to the distribution box. Using twisted feeders of equal length from the distribution box to the aerial investigate broadside and end-on radiation from this array. Indicate the horizontal polar diagram and justify your result.

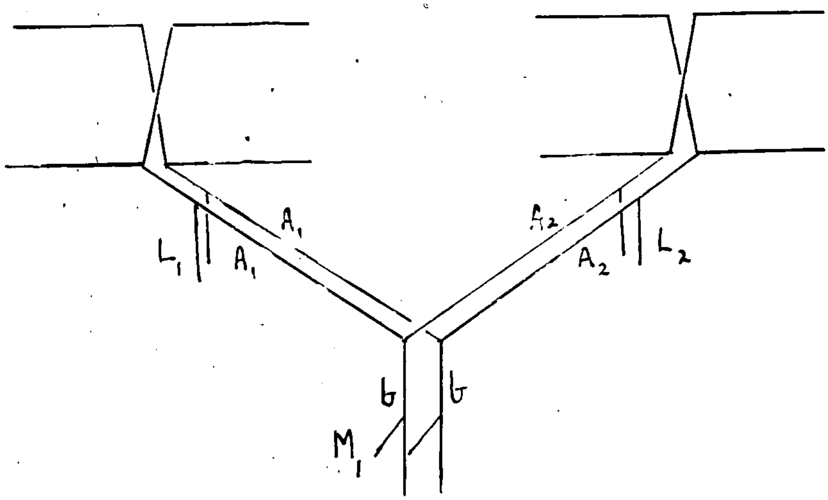
(b) Repeat the experiments using distribution feeders to the aerials such that the feeder lengths differ by $\frac{\lambda}{2}$.

Account for the difference in horizontal polar diagram of this array.

ment No.7:- Adjustments of 2 Bay 2 Tier Kooman's Array.

ooman arrays are used on H.F. working for consentrated adiation in a given direction and at a given vertical angle.

ll the dipoles associated with the Kooman's Array are inphase ed. The beam width is governed by the number of bays used, eing smaller as the number increases whilst the inclination of he main radiation lobe decreases as the number of tiers ncreases (One dipole $30^\circ$ - two dipoles $20^\circ$ - three dipoles $5^\circ$ - four dipoles $10^\circ$)




The lengths of aerials have been cut to $\frac{\lambda}{2}$ for 300 Mc/s operation

(a) Measure the starting wave ratio on the feeder sections A1, A1 and A2, A2.

(b) From the curve of fig:38(a) A.P.2514 obtain the lengths of matching stubs required.

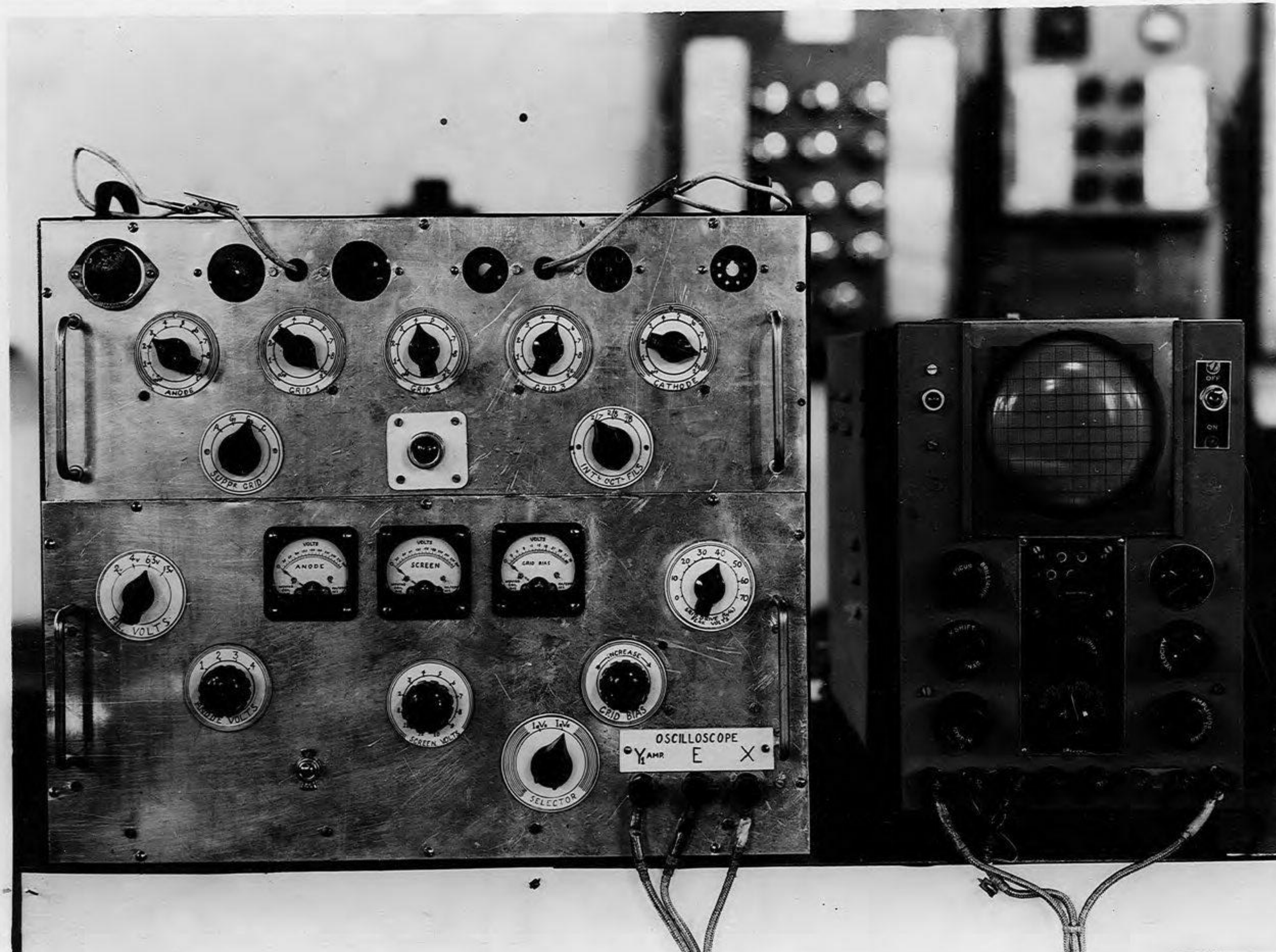
(c) Mount these stubs. $L_1 L_2$

(d) Repeat this procedure with the feeder section b b.

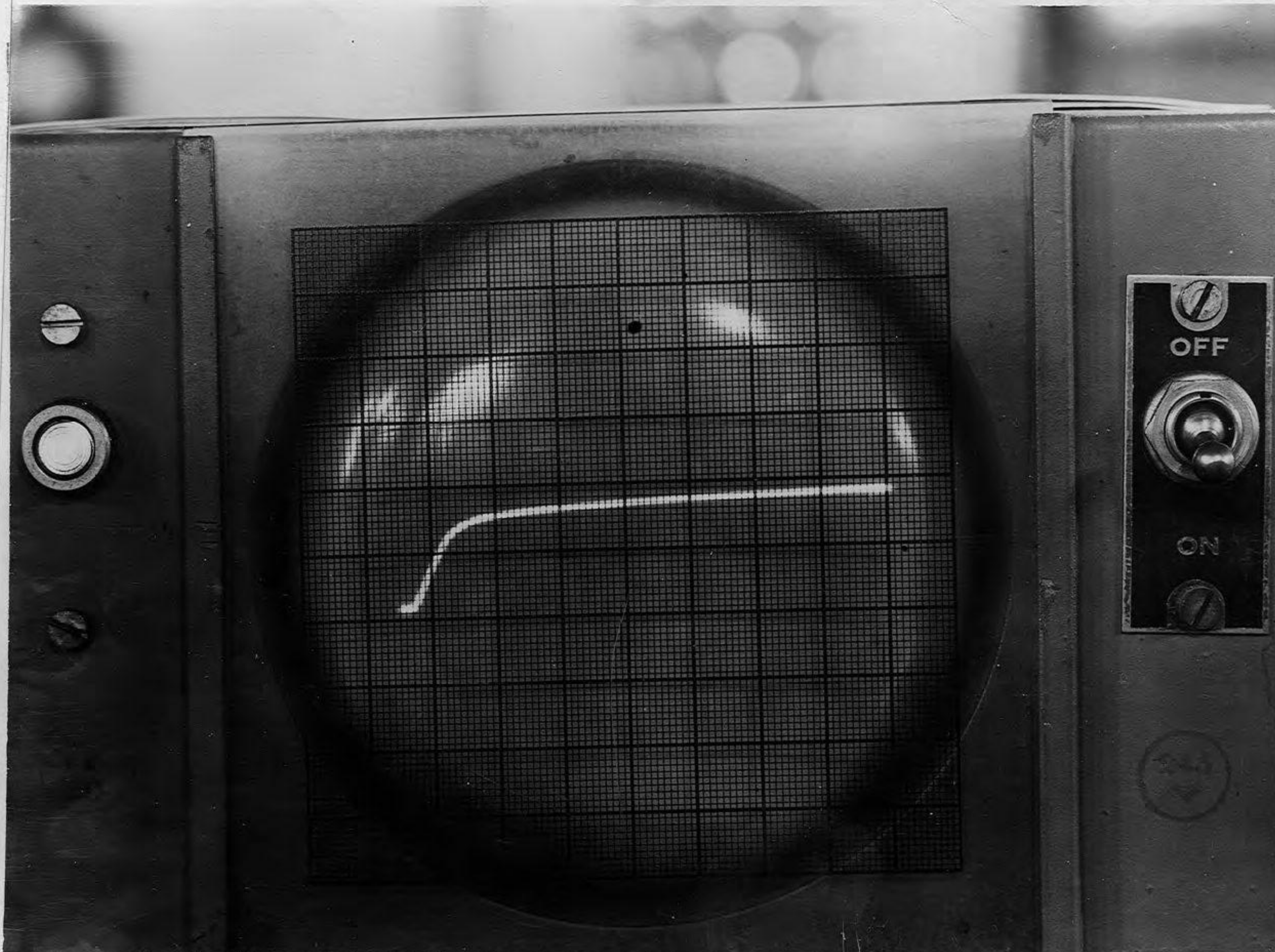
(e) Check the residual standing waves and if greater than 10% adjust last installed stub. $M_1$

Draw a diagram of the aerial system indicating current distribution on the Array and connecting feeders.

What other type of matching could have been used?

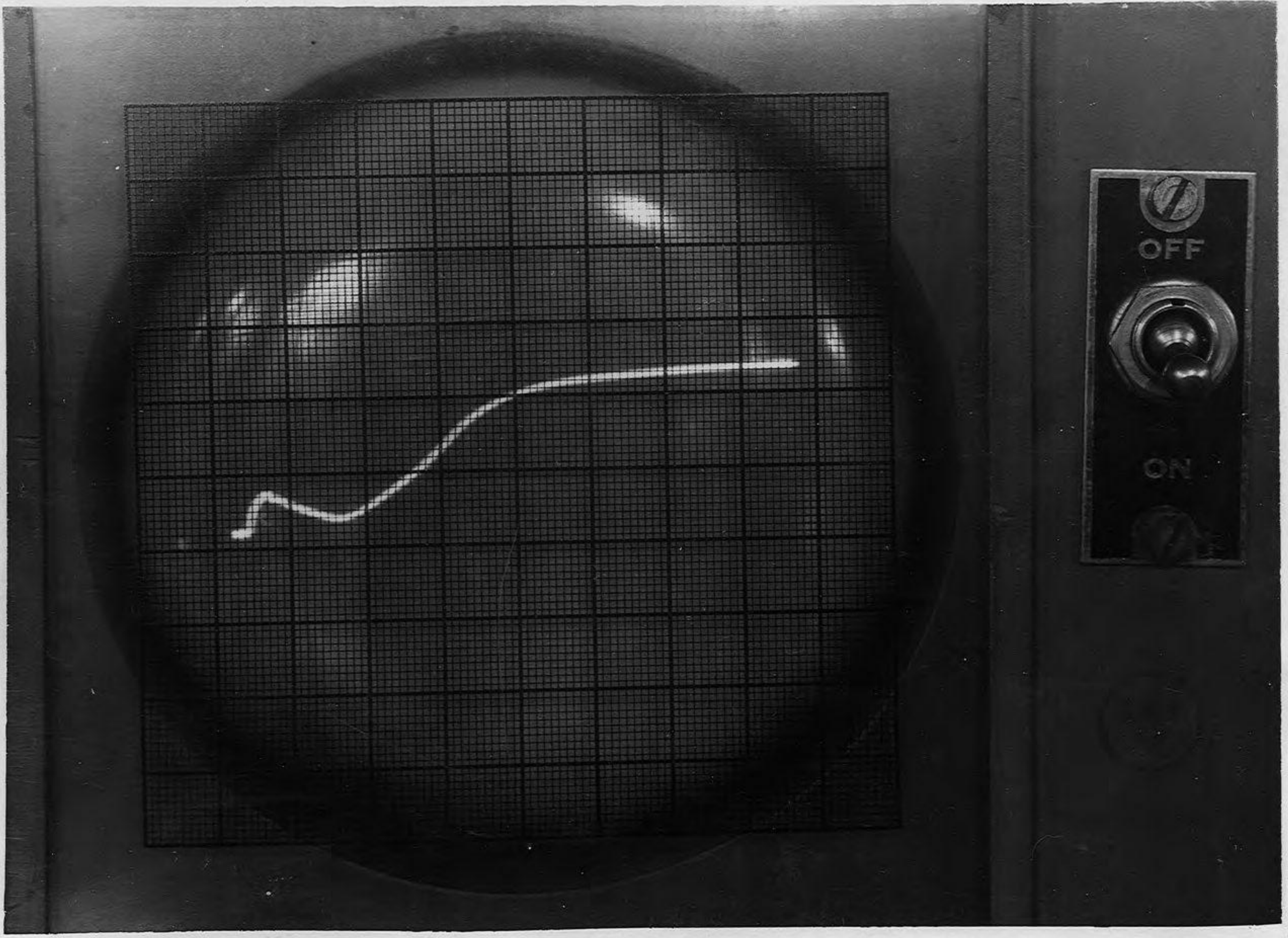



Valve
Characteristic
Demonstrator
and
Associated
Oscilloscope.



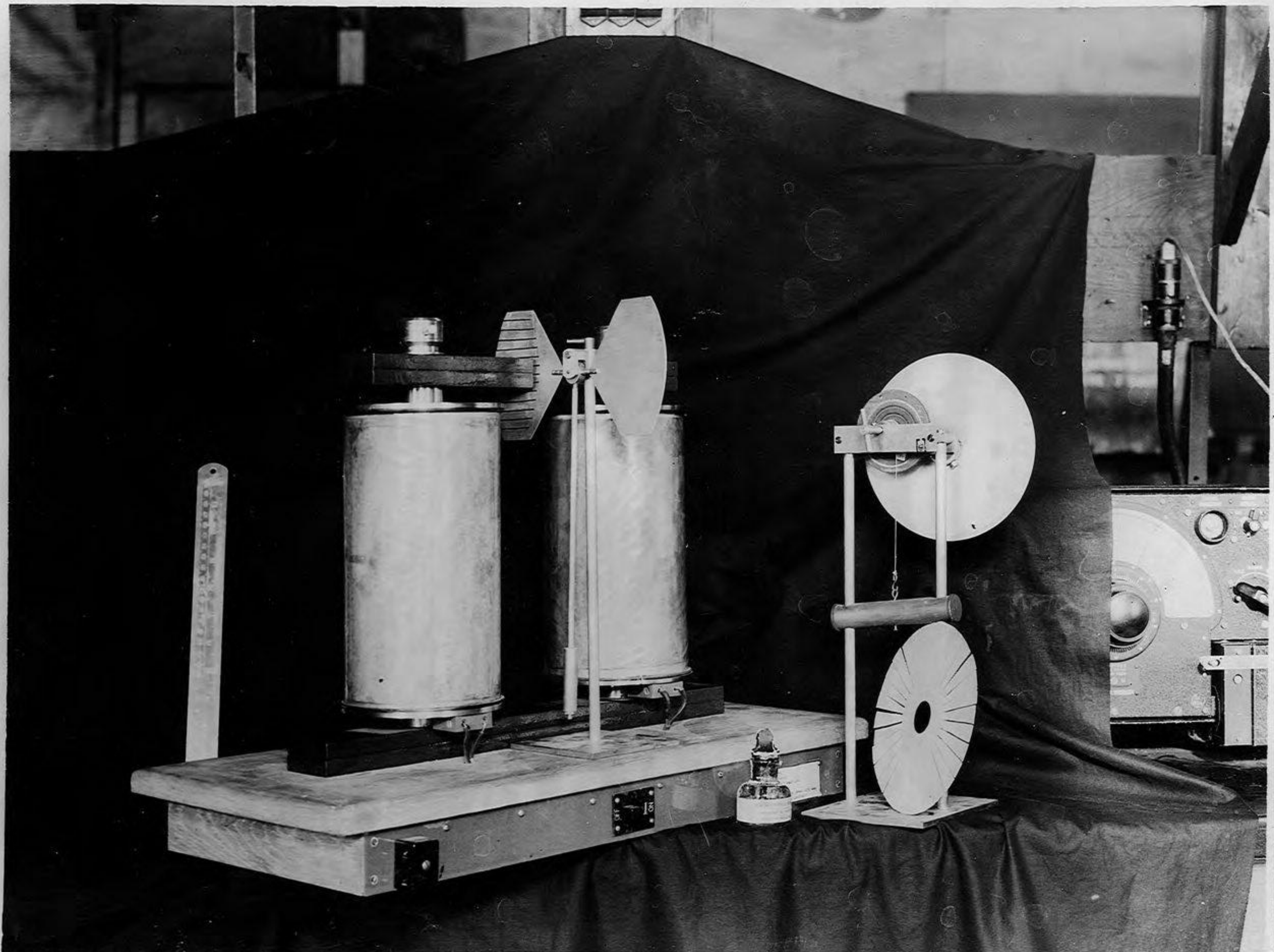

Anode Characteristic Oscillogram.

Valve Pentode Connected.

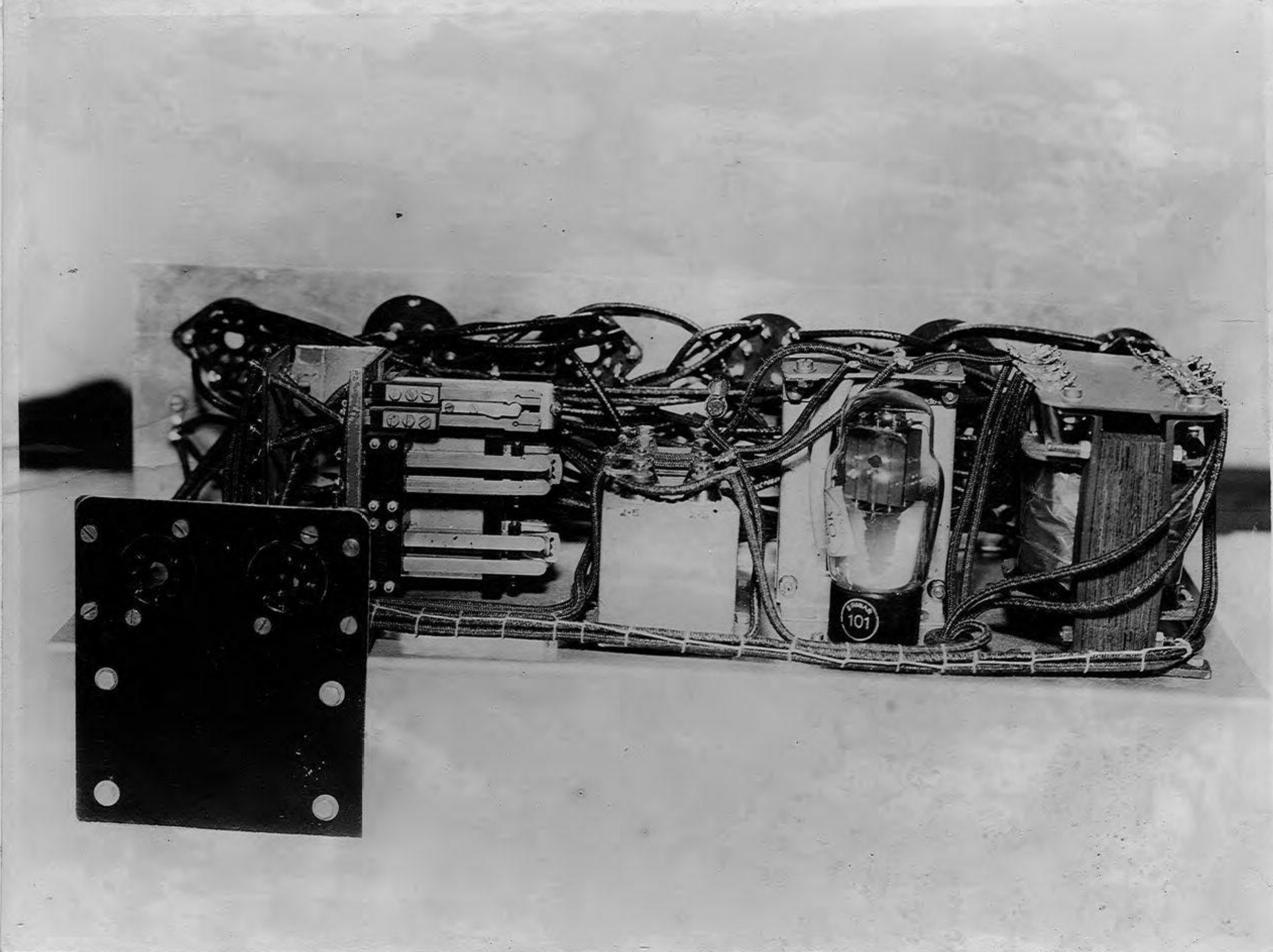



Anode
Characteristic
Oscillogram.

Valve Tetrode
Connected.

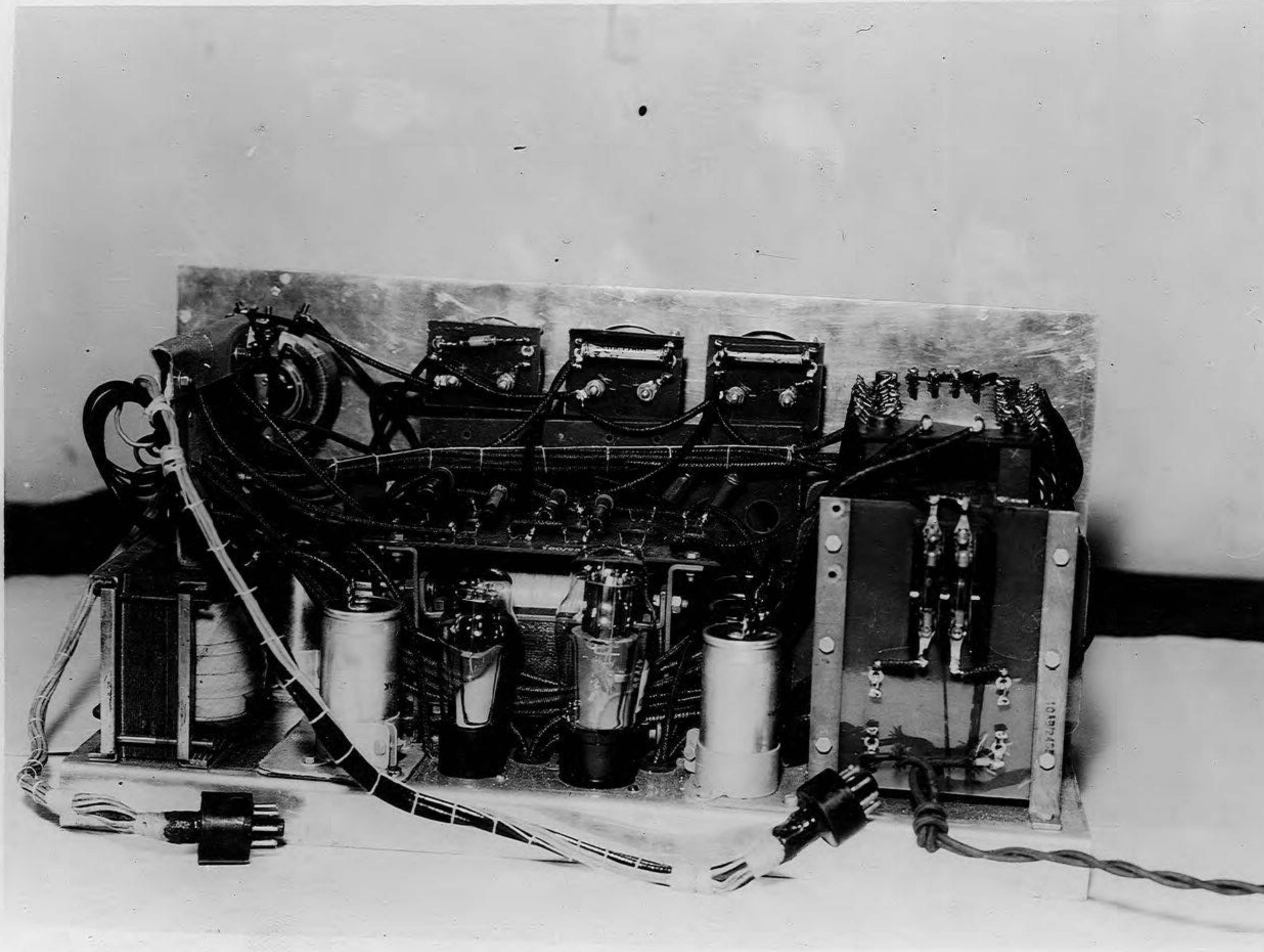


Eddy Current
Damping
Demonstration
Apparatus.




Valve
Characteristic
Demonstrator.

Anode Supply
Power Pack.



Valve
Characteristic
Demonstrator.
Power Pack
for
Screen and Bias
Supplies.